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THROUGH: Carol Rowan West, Director, ORS

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DATE: August 24, 2006

SUBJECT: Evaluation of Ambient Air Modeling Results for the Crow Lane Landfill, Newburyport, Massachusetts

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1.0 INTRODUCTION

In response to your request, the Office of Research and Standards (ORS) has reviewed the results of an ambient air computer dispersion modeling study of chemicals projected to be released from the landfill open flare at the Crow Lane Landfill in Newburyport, Massachusetts. This computer modeling study was conducted following sampling of the landfill gas by ENSR Corporation under contract to the Massachusetts Department of Environmental Protection (MassDEP) in response to continuing odor complaints from residents. This memo provides a description of the issue of concern, the modeling approach taken, the guidelines used by ORS to evaluate potential toxic effects and odors, as well as ORS' evaluation results and conclusions. The current memo follows a preliminary evaluation of the data addressed in a July 27, 2006 memo (MassDEP, 2006a) from Carol Rowan West, ORS to Richard Chalpin, Northeast Regional Office (NERO).

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2.0 BACKGROUND

2.1 Description of Landfill

The Crow Lane Landfill, owned and operated by New Ventures Associates, LLC, is a former municipal landfill that accepted a variety of solid wastes including municipal solid waste and sludge. The landfill is currently undergoing closure and using a variety of materials as shaping and grading material beneath the final cap, including "contaminated soil" under MassDEP Policy COMM-97-001 and fines and residuals (C &D Fines) produced from the processing of construction and demolition waste. The C & D Fines, which contain gypsum dust from gypsum wallboard, are the major source of the sulfate that results in the generation of hydrogen sulfide gas at the landfill. The Crow Lane Landfill has an active landfill gas extraction system in place, which then routes the gas to an open flare that oxidizes the constituents. Sulfur chemicals burned in the open flare are transformed to sulfur dioxide.

2.2 Description of Issue

The Crow Lane Landfill has been the source of numerous complaints from residents in the surrounding neighborhoods regarding noxious odors, headaches, nausea, eye and respiratory system irritation associated with landfill emissions and concerns about possible health effects. This issue was first brought to the attention of the MassDEP Office of Research and Standards (ORS) in August of 2005, when the MassDEP Northeast Regional Office (NERO) asked ORS to evaluate the results of ambient air monitoring data for hydrogen sulfide (H_2S) from the ambient air monitoring station located at 3 Charmanski Drive for the weekend of August 5-8, 2005. During that weekend the open flare had malfunctioned resulting in the venting of untreated landfill gas directly from the active landfill gas collection system to the abutting residential neighborhood. The results of ORS' evaluation confirmed the presence of H_2S at concentrations exceeding both an odor threshold (11 $\mu g/m^3$) and the one-hour public health guideline (42 $\mu g/m^3$) at the monitoring station and likely in the surrounding neighborhood during that event (MassDEP, 2005[1]). In the winter of 2005, ORS was asked to evaluate the results of the ambient air monitoring for H_2S from the same air monitoring station for November and December of 2005. The results of this second evaluation indicated that there were repeated instances of events when five-minute measurements of H_2S concentrations were above an odor threshold of 0.7 $\mu g/m^3$ (222 discrete events lasting from >10 minutes to almost 18 hours over the two month period). None of the one-hour running average concentrations exceeded a one-hour public health guideline of 42 $\mu g/m^3$ (MassDEP, 2006b)[2,3]. Both of these studies document the presence of

[1] A previous memo, from Michael Hutcheson to John Carrigan, dated August 24, 2005, and entitled "Evaluation of Hydrogen Sulfide Continuous Monitoring Data from August 5-8, 2005 from Wildwood Drive, Newburyport, MA" refers to the location of this monitor as Wildwood Drive, Newburyport. The MassDEP Northeast Regional Office has since informed us that this monitor was actually located at 3 Charmanski Drive, the same location described in the current memo.

[2] The August and November-December evaluations presented H_2S concentrations in part per billion (ppb). In the present evaluation they are presented in $\mu g/m^3$. The conversion factor between these units for H_2S is 1.38 $\mu g/m^3$ per ppb.

unpleasant, irritating and often noxious levels of H_2S in ambient air in the surrounding community.

In response to the continuing odor complaints and residents' concerns about potential exposure to sulfur dioxide (SO_2), a computer dispersion modeling study was conducted to examine the projected concentrations for several averaging periods of landfill-related sulfur chemicals and volatile organic chemicals in the ambient air at a number of receptor locations near the landfill. The computer dispersion modeling study focused on inlet and outlet concentrations of both sulfur chemicals and volatile organic chemicals at the open flare both to evaluate the potential risk posed by emissions from the open flare and to gain information about the need for additional landfill gas control and treatment systems in order to minimize the potential for adverse impacts from the emissions. This computer dispersion modeling study predicts maximum ambient air levels at nineteen (19) receptor locations resulting from emissions from the open flare, assuming that no pretreatment system is in place to remove reduced sulfur chemicals before the landfill gas is oxidized.

3.0 METHODS

3.1 Modeling Approach

The computer dispersion modeling study for this project was conducted for the MassDEP by ENSR Corporation (ENSR, 2006a, b). The focus of the modeling study was to estimate ambient air concentrations of landfill-related chemicals at nineteen (19) specific receptor locations, including schools, hospitals, elderly housing and residential areas surrounding the Crow Lane Landfill. Table 1 provides a list of the locations modeled. The computer dispersion model predicts chemical concentrations post-flaring assuming the current operating scenario for the open flare, as well as for a number of other open flare scenarios in which certain operating parameters (i.e., gas inflow rate, open flare location or addition of supplemental propane gas) are varied to identify potential future and/or more effective operating conditions. Propane gas is used as a supplemental fuel in the open flare when the methane concentration in the landfill gas is not sufficient to maintain combustion at the proper temperature.

[3] The odor threshold values for H_2S ranges from 0.014 to 1950 $\mu g/m^3$. A value for the odor threshold in the middle of the available range of odor thresholds was used in the August 2005 analysis. A lower value was used for odor threshold in the analysis of the Nov-Dec monitoring data, as a more sensitive measure of potential for odor issues.

Table 1. List of Locations for Which Computer Dispersion Modeling Was Conducted

Anna Jacques Hospital	Hale St. At Squires Glen Drive
Newburyport High School	3 Doe Run Drive
Davenport School	Doe Run Dr. @ turnaround
Currier School	Wildwood @ Quail Run Hollow
Belleville School	3 Charmanski Drive (monitor)
Bresnahan School	Day Care Center
Country Manor Rehab. and Nursing Center	Low Street @Murphy Street
Elderly Housing off Low Street	K-Mart @ Low Street
Knox Middle School	Merrimac Place Assisted Living
Acute Care/Rehab. Facility @ Hale & Low St.	

An initial screening modeling study using the U.S. Environmental Protection Agency's (EPA) AERSCREEN computer dispersion model was conducted in May 2006 in order to provide generic upper-limit concentration estimates at each of the specified locations and to identify the operating scenarios to be modeled using EPA's AERMOD Model (ENSR, 2006a). To obtain more realistic yet still conservative estimates of these concentrations, refined computer dispersion modeling was conducted using the advanced EPA model, AERMOD, using two years of hourly surface meteorological data from the Portsmouth/Pease Airport (ENSR, 2006b). The computer dispersion model was applied to emission rates in grams per second (g/sec) that were estimated based on landfill gas samples collected by ENSR in March 2006 (ENSR, 2006c). Computer dispersion model output, calculated on an emission rate of 1 g/sec, includes ambient air concentrations for each one-hour period for 2004 and 2005. From this information, the computer dispersion model was used to calculate ambient air concentrations for each of five averaging periods, (including four acute averaging periods - i.e., one-hour, 3-hour, 8-hour and 24-hour and an annual averaging period) and to identify the highest concentration for each averaging time for each receptor location (maximum average concentrations). The acute averaging periods used in the modeling study are consistent with the time scale of the fluctuation of H_2S concentrations observed during the monitoring at the landfill (MassDEP, 2005, 2006b). The means over each averaging period were calculated as sequential averages, rather than running averages.

These predicted concentrations were modeled for both volatile organic chemicals (VOCs) and for sulfur chemicals, i.e., chemicals that were detected following analysis for VOCs, sulfur chemicals, arsine and mercury in the March 2006 landfill gas samples (ENSR, 2006c). Arsine and mercury were not detected in the landfill gas and therefore, were not modeled. The sulfur chemicals modeled included hydrogen sulfide (H_2S), carbonyl sulfide (COS), methyl mercaptan, ethyl mercaptan, dimethyl sulfide, isopropyl mercaptan, t-butyl mercaptan, ethyl methyl sulfide, dimethyl disulfide, carbon disulfide and sulfur dioxide (SO_2). The active landfill gas extraction system and open flare have only been operating for about a year (from June 13, 2005). However, the refined dispersion model used two years of meteorological data (2004 and 2005) to more accurately represent the range of meteorological conditions that could be anticipated to occur at the site over a longer modeling period.

Six cases or operating scenarios were identified for evaluation with this model. These are listed in Table 2. The flow rate measured at the open flare at the initiation of modeling activities in March 2006 was 23 cubic feet per minute (cfm). A higher flow rate of 130 cfm, agreed upon by the MassDEP engineers and modelers for this project, was assumed to likely represent the design rate for the existing landfill gas extraction system. The system may have at times operated at approximately this flow rate. The effect of moving the open flare to the top of the landfill was also modeled. Since this facility has used supplemental propane to bolster the flame, estimates both with and without supplemental propane were made for each of the cases described above. The use of supplemental propane results in an increase in the total heat release rate factor used in the computer dispersion modeling and increases in the buoyancy flux, reducing the impacts of dispersion on the receptors.

The computer dispersion model assumes an oxidation efficiency of 80%, which may be a conservative estimate given that, when operating properly, the open flare is designed to oxidize VOCs and reduced sulfur chemicals with an efficiency of 90% or greater. For sulfur dioxide (SO_2) it is assumed that 100% of sulfur chemicals are oxidized to SO_2; thus, under this assumption, the 20% of reduced sulfur chemicals that are not oxidized are conservatively double-counted.

Table 2. List of Cases Modeled

Case	Location of Open Flare	Flow Rate (cfm)	With or Without Supplemental Propane
Case 1A	Current Location	23	Without
Case 1B	Current Location	23	With
Case 2A	Current Location	130	Without
Case 2B	Current Location	130	With
Case $2A_{Top}$	Top of the Landfill	130	Without
Case $2B_{Top}$	Top of the Landfill	130	With

3.2 Evaluation of Computer Dispersion Modeling Output

The approach used by ORS to evaluate the computer dispersion modeled maximum average concentration data was to identify guidelines to be protective of public health for each of the modeled chemicals and to compare the maximum modeled concentrations to these guidelines. The comparison of modeled data to the guidelines was conducted using a Hazard Index (HI) approach. A HI is the ratio of the exposure point concentration (in this case, the computer dispersion modeled ambient air concentration) to the guideline. A HI was calculated for each chemical for each receptor location, averaging time and case. A HI greater than 1.0 indicates that the predicted concentration for that chemical, averaging time and location exceeds the chemical-specific guideline. A total HI, which is calculated by adding the individual HIs for each chemical, was also calculated for each receptor location, averaging time and case. A total HI is an indicator of the potential cumulative effects of a

group of chemicals that act by a common toxicological mechanism and produce similar sorts of effects. A total HI greater than 1.0 indicates that the potential for health effects posed by that group of chemicals cannot be ruled out.

In addition, a list of available chemical-specific odor thresholds was compiled. An informal comparison to these odor thresholds, when available, was also conducted to determine the magnitude of potential exceedance of the odor threshold.

3.2.1 Public Health Guidelines

VOCs: The modeled VOC maximum average concentrations predicted with the AERSCREEN computer dispersion model were screened for potential health impacts using available chronic toxicity values for the modeled chemicals. These included EPA inhalation Reference Concentrations (RfCs) and inhalation unit risks (URs) as well as MassDEP Threshold Effects Exposure Limits (TELs) and Allowable Ambient Limits (AALs). Comparison of acute and annual modeled concentrations (i.e., shorter averaging times) to these chronic values (longer averaging times) is very conservative as, in general, the shorter the averaging time, the higher the concentration.

An inhalation RfC is an estimate (with uncertainty spanning perhaps an order of magnitude) of a continuous inhalation exposure concentration of a chemical to the human population (including sensitive subgroups) that is likely to be without an appreciable risk of deleterious noncancer health effects during a lifetime. RfCs are contained in the EPA Integrated Risk Information System (IRIS) database. The predicted Crow Lane screening concentrations were reviewed and it was determined that none of these concentrations were greater than approximately 1×10^{-3} $\mu g/m^3$. Rather than performing a chemical by chemical assessment of predicted concentrations versus RfCs, a more efficient assessment was performed by scanning all the RfCs on IRIS to determine whether any of these criteria were 1×10^{-3} $\mu g/m^3$ or below in magnitude. There were no RfCs for VOCs below this value, meaning that all predicted concentrations were lower than the RfC. In fact, they were lower by at least two orders of magnitude.

In order to determine whether or not any of the predicted concentrations would present an unacceptable excess lifetime cancer risk (ELCR) greater than 1×10^{-6} ,or one-in-one-million) after lifetime exposure, we determined how large the unit risk value for any chemical would have to be to represent an ELCR greater than 1×10^{-6} given the maximum predicted concentrations were not greater than 1×10^{-3} $\mu g/m^3$. Unit risks are standardized estimates of the magnitudes of carcinogenic risks posed by chemicals and are the ELCRs associated with lifetime exposures to concentrations of the chemicals at 1 ug/m^3. This UR would be 1×10^{-3} per $\mu g/m^3$. The IRIS list of toxicity values was then searched to identify any UR greater than 1×10^{-3}. There were none for any VOCs. Therefore none of the predicted concentrations would be associated with ELCRs greater than one-in-a-million after lifetime exposure.

TELs and AALs are conservatively derived health-based ambient air guidelines that are protective of public health and are available for a large number of VOCs. They assume chronic exposure to the chemical for a lifetime. A comparison of all modeled screening concentrations to the TELs and AALs indicated that the modeled concentrations were much lower, often by several orders of magnitude. A list of TELs and AALs is contained in Appendix D.

Given that the computer dispersion modeled concentrations represent maximum average concentrations and are still well below these conservative air guidelines, it was concluded that the potential for adverse health impacts from VOC exposures on the surrounding community is negligible and VOCs were not evaluated further from the refined modeling data set.

Sulfur Chemicals: A survey of EPA, Agency for Toxic Substances and Disease Registry (ATSDR), California Environmental Protection Agency (CA EPA) and other agencies as well as the toxicological literature was done to identify available public health guidance or, alternatively, toxicological information for the sulfur chemicals in the landfill gas upon which such guidelines might be developed. A list of available public health guidelines was compiled and the bases for these values were reviewed to select the most appropriate value for evaluation of these data.

In general, the toxicity database for sulfur chemicals is limited. The toxicity database for the one-hour and annual averaging times is somewhat better than it is for the other averaging times. Toxicity information for the 3-hour, 8-hour and 24-hour averaging times is generally lacking for most of the chemicals. As a result, ORS' evaluation of the computer dispersion model output data focused mainly on the one-hour and annual averaging periods. Moreover, use of the one-hour and annual averaging periods permits evaluation of health effects from the short-term fluctuations in emission concentrations as observed in the monitoring studies (MassDEP, 2005, 2006b) as well as potential for long-term health effects. Table 3 identifies the list of chemical-specific guidelines identified for the one-hour and annual averaging times. The predicted annual average concentrations were compared to guidance values derived for subchronic exposure periods lasting up to 7 years. Appendix A at the end of this memo provides the documentation for selection and/or derivation of the guidelines contained in Table 3.

Many of the available acute one-hour guidelines from the sources listed above are based upon acute action levels (e.g., Acute Exposure Guideline Level (AEGL), Emergency Response Planning Guideline (ERPG)). Acute action levels for chemicals are generally exposure concentrations at or above which some type of adverse health effect is likely to occur and at which some sort of response action usually is recommended. They therefore are not necessarily health protective and are higher than levels developed to be protective of public health. To estimate one-hour no adverse effect levels protective of public health, ORS lowered the acute action levels that are based on observed minimal adverse effect levels by a factor of three

(3). This step is consistent with the application of uncertainty factors by EPA to account for the extrapolation of a minimal effect level to a no effect level.

As is discussed in section 4.0, the key risk drivers in this evaluation were identified as H_2S, COS and SO_2. The guidelines identified for these chemicals are discussed in this Section (3.2.1). For additional information on the guidelines identified for the remaining sulfur chemicals, please refer to Appendix A.

Table 3. List of Guidelines Used to Evaluate Modeled Concentrations

Chemical	**One-Hour Average** ($\mu g/m^3$)	**Annual Average*** ($\mu g/m^3$)
Hydrogen sulfide	42	20
Carbonyl sulfide	42	20
Methyl mercaptan	3	1
Ethyl mercaptan	850	1
Dimethyl sulfide	420	11
Isopropyl mercaptan	850	1
t-Butyl mercaptan	850	1
Ethyl methyl sulfide	420	11
Dimethyl disulfide	13	11
Carbon Disulfide	4100	700
Sulfur Dioxide	660	80

* Based on guidance values developed for subchronic exposure durations, defined to correspond to a period of about two weeks to seven years

For H_2S, Table A-1 in Appendix A lists a range of guidelines that have been identified for the one-hour exposure duration. The bases for derivation of these numbers are contained in Appendix A. California's H_2S value of 42 $\mu g/m^3$ for one-hour exposures is an ambient air quality standard (AAQS) not to be equaled or exceeded, derived to be protective of adverse effects in a human population, including sensitive subgroups (CA EPA, 2006). It represents the mean of the odor threshold reported by 16 individuals and is therefore based on health effects associated with perception of odor.

It is difficult to determine where to set a health-based guideline for a chemical with an odor threshold significantly below the level where toxicologically adverse effects occur. While exposures to concentrations exceeding a chemical's odor threshold do not necessarily result in adverse health effects, for H_2S these exposures can result in clearly unpleasant health effects including nausea and headache. The sensitivity to H_2S odors and health effects within the human population ranges over orders of magnitude. At high H_2S concentrations (2800 $\mu g/m^3$), above the odor threshold for most people, health effects that are adverse in nature (e.g., increased airway resistance) have been reported.

The key point for this evaluation is that the guideline of 42 $\mu g/m^3$ for H_2S is

based on observed health effects in humans, and is also a level at which odors are perceived. However, even California acknowledged that their standard might need to be reexamined in light of other information, including one study that concluded that 83% of the population would detect an odor at 42 $\mu g/m^3$ and 40% would find this level to be an objectionable concentration (Amoore, 1985). The California Air Resources Board in public testimony noted that some people reported headaches and other symptoms at concentrations less than 42 $\mu g/m^3$.

ORS has been developing acute guidance for H_2S although this number is not final and has not yet been published. ORS' guidance for H_2S will be made public once it has been finalized. Consistent with the preliminary evaluation (MassDEP, 2006a), ORS has employed the California value of 42 $\mu g/m^3$ for this evaluation. However, based on the discussion on H_2S provided above, ORS believes that a health protective one-hour guidance value for H_2S may be lower than the California value of 42 $\mu g/m^3$ in order to consider the more sensitive individuals in the population. Three states, including New Mexico, New York and Kentucky have a one-hour ambient air standard for H_2S of 14 $\mu g/m^3$. New York regulations state that the primary objective of this value is to prevent disagreeable odors (NYS DEC Rules and Regulations, Subpart 257-10). At an ambient air concentration of 14 $\mu g/m^3$, it has been estimated that 56% of people will detect H_2S and 17% will find it annoying (Amoore, 1985). (See Appendix A for additional information on the basis of this guideline.)

Because of the apparent uncertainty of where a public health protective level of H_2S lies, ORS repeated this evaluation using the one-hour value of 14 $\mu g/m^3$ adopted by New Mexico/New York/Kentucky to put some boundary on the range of potentially adverse exposure conditions represented by the modeled air concentrations.

As discussed in Appendix A, H_2S is a metabolite of carbonyl sulfide (COS). Thus, ORS employed the H_2S guidelines for COS.

For SO_2, the EPA National Ambient Air Quality Standards (NAAQS) for the twenty-four hour and annual averages were used for comparison to their respective averaging times[4]. ORS chose to employ the one-hour average-based California Air Resources Board ambient air quality standard of 660 $\mu g/m^3$ for this evaluation, in preference to criteria with longer-term averaging periods, because this short-duration averaging period most closely matched the scale of variation seen in the H_2S monitoring studies (MassDEP, 2005, 2006b) for this landfill. California has based its one-hour SO_2 standard on susceptible subpopulations within the population, specifically persons with asthma. Thus, an exceedance of this value indicates the potential for a person with asthma to experience adverse health effects. People without asthma would be less likely to experience adverse health effects at this concentration.

[4] NAAQS for the 24-hour averaging time is not to be exceeded more than one time per year (EPA, 2006).

3.2.2 Odor Thresholds

The threshold at which individuals may perceive odors varies among individuals. Such variability in sensitivity to odor has health implications with chemicals such as reduced sulfur chemicals that trigger health effects in response to odors. A brief survey of odor thresholds was conducted and some of the measured values from the literature are presented in Table 4.

Table 4. Odor Thresholds for Sulfur Chemicals in μg/m^3

Chemical	Critiqued Odor Detection Threshold Values [a]	Critiqued Odor Recognition Threshold Values [a]	Warning concentrations [b]	Level of Distinct Odor Awareness (LOA)[c]	Odor Threshold Values[d]
Hydrogen sulfide	1.4 - 180	6	0.014 - 1950	14	0.7 – 14
Carbonyl sulfide	---	---	---	---	---
Methyl mercaptan	0.0004 - 80	2	---	4	0.04 – 82
Ethyl mercaptan	0.25 – 7.6	1	1.3 - 190	0.02	0.032 – 92
Dimethyl sulfide			2.5 - 50	---	2.5 – 50
Isopropyl mercaptan			0.8	---	
t-Butyl mercaptan			0.3 - 220	---	1.6 – 3
Ethyl methyl sulfide				---	
Dimethyl disulfide			30[e]	---	0.1 – 3400
Carbon disulfide	NA	NA	3 – 24,000	---	24 – 2300
Sulfur dioxide	7000	11,500	525 – 13,000	---	---

[a] Patty, 2000. These values were selected by Patty's from "Odor Thresholds for Chemicals with Established Occupational Health Standards (AIHA)"
[b] Mann, 1991. "A warning concentration is that concentration in air at which a person can detect the material either by its odor, by its taste or by it causing irritation. Warning thresholds are generally odor thresholds."
[c] EPA, 2006.
[d] Ruth, 1986
[e] Fazzalari,1978.

The various sources of odor thresholds define their criteria somewhat differently. Patty's Industrial Hygiene (2000) differentiates between the threshold at which an odor is perceived and the threshold at which can be identified. Mann (1991) refers to odor thresholds as "warning concentrations" that are taken as an indication of their presence as a result of their detection via the olfactory system or by their causing health effects. The EPA AEGL Development Team has identified a level of distinct odor awareness that represents a concentration at which it is predicted that more than 50% of the exposed population will experience a distinct odor intensity and at least 10% will experience a strong odor intensity. Ruth (1986) collated the odor threshold data present in the industrial hygiene literature and other sources. While the definitions may vary, the information in Table 4 illustrates the range of odor

sensitivities to the reduced sulfur chemicals. It is noted that several reduced sulfur chemicals, particularly the mercaptans, have extremely low odor thresholds and thus can be identified at very low concentrations potentially before health effect levels are reached. Alternatively, SO_2 has a very high odor threshold, often at levels that are higher than health guideline concentrations. Therefore, odor might serve as a warning indicator of potential health effects for mercaptans but not for SO_2.

3.2.3 Risk Evaluation

The maximum average concentrations, assuming an 80% open flare destruction efficiency for each chemical, case, location and averaging time were compiled into an Excel spreadsheet and an HI was calculated for each concentration, using the averaging-time-specific public health guideline for that chemical. A total HI was also calculated for each location by adding the individual HIs for each chemical in the list. Exceedances of the guideline were highlighted and the results were also reviewed to identify the chemical risk drivers, or, the chemicals that contributed the most to the risk. The evaluation also identified the cases, averaging times and locations with the highest risk and/or of the most concern.

These particular cases were further evaluated by observing the number of times over the two years of meteorological data that the driver chemical(s) time-averaged concentration(s) exceeded public health guidelines. Because the modeled results assumed a worst-case destruction efficiency of 80% for the open flare, the number of exceedances assuming open flare efficiency of 90% (i.e., optimal design) were also determined.

Frequencies of exceedances of public health guidelines were determined by identifying the number of one-hour averages that exceeded guidelines at each receptor location, and dividing this number by the total number of hours modeled over the two years. There was some missing meteorological data and calm hours during the two year period for which the model does not calculate concentrations (about 10% of the time) (ENSR, 2006b). The actual total number of hours modeled over the two years was therefore 15,767. ORS extrapolated this frequency for each location proportionately to a complete two-years of sequential one-hour periods (i.e., 17,520 one-hour intervals) to obtain an estimate of exceedances per year for each location.

Conclusions regarding the potential health effects of these projected emissions thus consider not only the magnitude of the exceedances but also their frequency.

As stated above, based on the fact that the toxicity database for the 3-hour and 8-hour averaging times was very limited, this evaluation focused on the one-hour and annual averaging times. However, a review of the 24-hour acute results was conducted mainly to evaluate whether any of the predicted 24-hour SO_2 values exceeded the 24-hour NAAQS.

4.0 RESULTS

4.1 Overall Trends and Selection of Cases for Further Analysis

A review of the refined computer dispersion modeling (AERMOD Model) results indicated a number of trends in the data.

- Modeled concentrations were higher under those scenarios that assumed the open flare would remain in its current location.
- Concentrations were lower in those cases that assumed the open flare would be moved to the top of the hill.
- Modeled concentrations based on a flow rate of 130 cfm were higher than concentrations modeled at 23 cfm.
- Modeled concentrations were lower in cases that assumed the addition of supplemental propane.

As a result, of the cases described in Table 2:

- The highest modeled concentrations were determined for Case 2A, in which the open flare is maintained in its current location, with the higher flow rate of 130 cfm with no supplemental propane.
- The lowest modeled concentrations were determined for the top of the landfill hill scenario with supplemental propane.
- The rest of the cases were characterized by concentrations intermediate between these two extremes.

The results of the HI evaluation for all of the cases are attached as Excel Spreadsheets in Appendix B at the end of this memo. However, to evaluate a range of flow rates based on relevancy of the results to current and future operating conditions, ORS and NERO selected Case 1A and 2B for further analysis. Case 1A was chosen because it represents a lower-flow operating scenario in which supplemental propane is not provided.

Case 2B represents a higher-flow operating scenario for the open flare's present location but with the provision of supplemental propane as NERO engineers believed that, under this higher flow scenario, use of propane would be necessary under actual conditions. These cases were evaluated for the one-hour and annual averaging times. The results of these analyses are discussed below.

4.2 Evaluation of Predicted One-Hour Average Concentrations

In general, the one-hour acute analysis resulted in the greatest number of locations at which guidelines were exceeded for both Case 1A and Case 2B modeled maximum one-hour average concentrations. Tables 5 -8 provide summaries for Case 1A and Case 2B of the chemicals and number of locations that exceed their guidelines as well as the number of locations that exceed the total HI of 1.0. The range of HIs

associated with these exceedances is also summarized. To see a more detailed listing of locations and HIs, see Appendix B.

The results of this analysis indicate that the only chemicals that at any time exceeded their individual guidelines for these two cases are H_2S, COS and SO_2. Under lower flow conditions (i.e., 23 cfm flow rate, with the open flare at the current location) represented in Case 1A, the maximum one-hour average concentration of H_2S slightly exceeded its one-hour guideline at three locations (HI range 1.2 – 1.3)(Table 5). No other chemical individually exceeded its guideline for this case although the total HI (representing the contribution of all chemical-specific HIs) for each location exceeded 1.0 at seventeen (17) locations (i.e., total HI range 0.8 – 2.9 across all nineteen (19) locations)[5]. Under the higher flow scenario represented by Case 2B (i.e., 130 cfm flow rate, with the open flare at the current location) H_2S exceeded its one-hour guideline at 15 locations (HI range 1.2 – 3.1) and SO_2 exceeded its one-hour guideline at 12 locations (HI range 1.0 – 2.2). The total HI for each location exceeded 1.0 at eighteen (18) locations (i.e., total HI range 0.9 – 7.1 across all nineteen (19) locations). None of the predicted 24-hour or annual maximum average concentrations exceeded their respective NAAQS standard for SO_2. A comparison of lower to higher flow conditions indicates that without pre-treatment to remove the sulfur chemicals prior to combustion as the flow of landfill gas increases, ambient concentrations of sulfur chemicals and associated risks also increase.

Table 5. Summary of Exceedances of One-Hour Guidelines and Total Risks for Cases 1A and 2B Using 42 μg/m^3 for H_2S (Assuming 80% Open Flare Destruction Efficiency)

Chemicals Exceeding Guideline	# Locations Where the Chemical Guideline is Exceeded (19 total locations)	Range of Chemical HIs Associated w/Exceeded Guideline	# Locations Exceeding a **Total HI** of 1.0	Range of **Total HIs** Across All 19 Locations
CASE 1A				
H_2S	3	1.2 – 1.3	17	0.8 – 2.9
CASE 2B				
H_2S SO_2	15 12	1.2 – 3.1 1.0 – 2.2	18	0.9 – 7.1

[5] Evaluation of the H_2S one-hour concentrations for Case 1B, lower flow (23 cfm) with supplemental propane, predicted no exceedances of the H_2S and SO_2 guidelines. Total HI exceeded 1.0 at seven (7) locations with total HI for these locations ranging from 1.2 to 1.7 (Appendix B).

The computer dispersion modeled concentrations represent the maximum average concentration for each chemical over the entire two-year modeling period, and therefore the highest estimated risk for each chemical and location. However, these data do not indicate the actual number of times (or frequency) over the two years modeled that predicted concentrations would exceed public health guidelines. These frequencies were determined from the computer dispersion modeling results as described in section 3.2.3.

The analysis of frequencies of exceedances at locations with at least one exceedance indicates that under lower flow conditions (Case 1A) assuming no supplemental propane is burned, an 80% open flare efficiency would produce between 7 and 14 exceedances of the H_2S one-hour guideline per year at three (3) receptor locations (Table 6). If a 90% open flare efficiency is assumed, no exceedances of the H_2S value would be predicted. Under Case 2B higher flow conditions, assuming the use of supplemental propane, up to 83 H_2S exceedances (i.e., 83 one-hour durations) would be predicted assuming an 80% open flare efficiency and up to 29 H_2S exceedances per year would be predicted at the most impacted location assuming a 90% open flare efficiency. Tables providing the frequency of exceedances for each location are presented in Appendix C.

Table 6. Frequency of Predicted Exceedances of One-Hour Guideline for Cases 1A and 2B Using 42 μg/m^3 for H_2S for Both 80% and 90% Destruction Efficiency

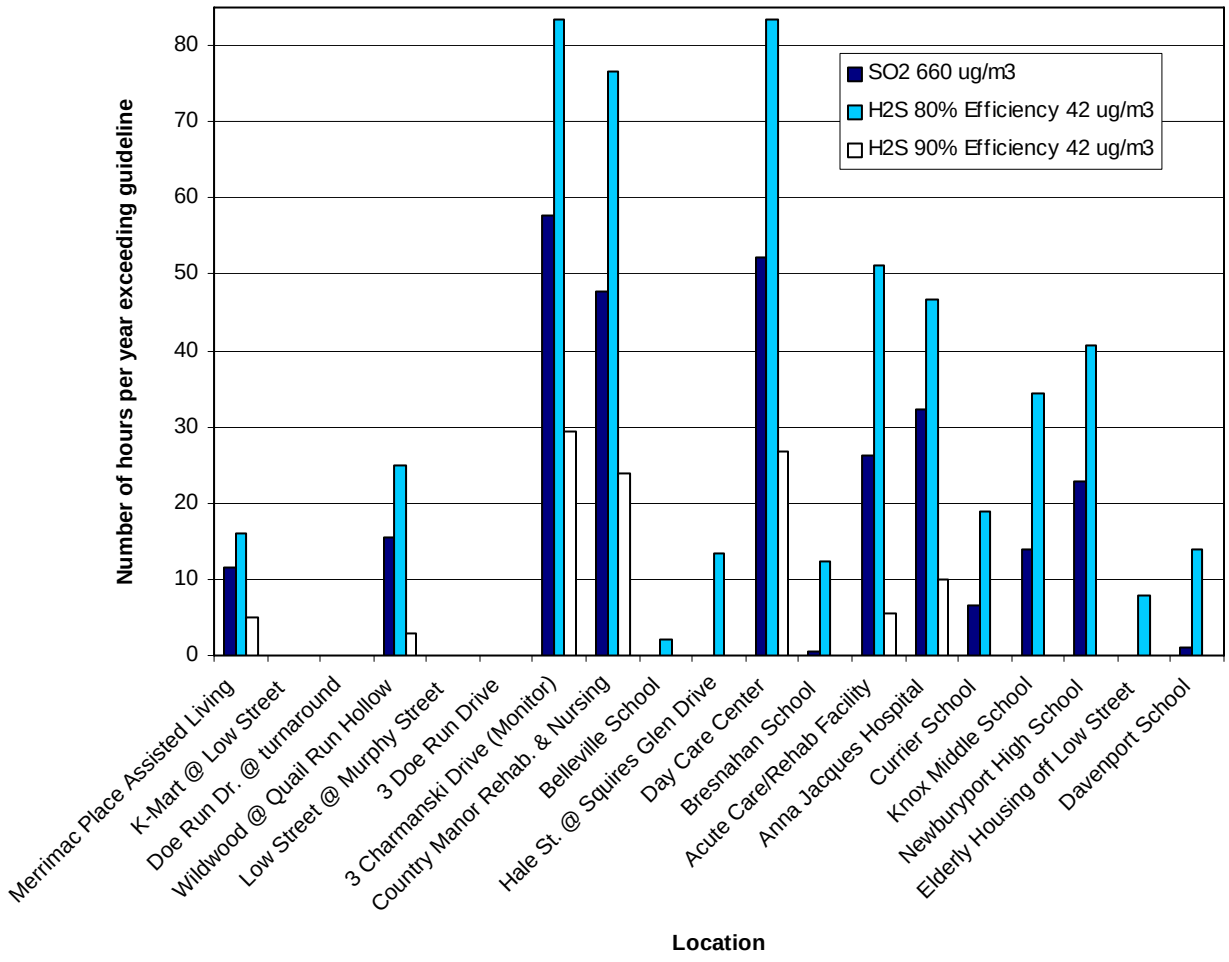
Chemical Exceeding Guideline	Range of Predicted One-Hour Exceedances per Year at 80% Open Flare Efficiency In Locations Exceeded	Range of Predicted One-Hour Exceedances per Year at 90% Open Flare Efficiency In Locations Exceeded
	CASE 1A	
H_2S	7 - 14	0
	CASE 2B	
H_2S	2 - 83	3 - 29
SO_2	1 - 58	1 - 58

A review of the SO_2 evaluation results indicates that, under the lower-flow open flare operating conditions represented in Case 1A, no exceedances of the SO_2 one-hour guideline should result. Under the higher flow conditions represented in Case 2B, there may be up to 58 exceedances per year of the one-hour SO_2 guideline at the most impacted location. It should be noted, as discussed above, that the SO_2 predicted concentrations might be overestimated by 10 - 20%. The model assumes

that 100% of reduced sulfur chemicals are converted to SO_2, even though either 20% (for the 80% efficiency) or 10% (for the 90% efficiency) of the reduced sulfur chemicals are not assumed to be oxidized.

Nevertheless, multiple exceedances of the SO_2 guideline are predicted to occur at the higher gas flow rate. Even assuming 80% efficiency and reducing the estimated SO_2 concentration by 20% to account for the overestimate described above, there would still be up to about 41 exceedances of this guideline predicted per year. Figure 1 illustrates the location and number of predicted exceedances of H_2S and SO_2 guidelines assuming 90% and 80 % destruction efficiency.

Figure 1. Case 2B High Gas Flow Rate: Frequency of Exceeding H_2S Guideline of 42 μg/m^3 and SO_2 Guideline of 660 μg/m^3:



4.3 Evaluation of Predicted One-Hour Values Using the Guideline of 14 μg/m^3 for H_2S and COS

As discussed above, the modeling results were also evaluated using 14 μg/m^3 for H_2S and COS. Use of the lower guideline increased the predicted number of exceedances and range of HIs. The results of this evaluation indicate that predicted H_2S concentrations exceeded the value of 14 μg/m^3 at all 19 locations under both Case 1A (lower flow)[6] and 2B (higher flow) conditions (HI range 1.1 – 9.4). In addition, under Case 2B, COS also exceeded its one-hour guideline at 6 locations (HI range 1.1 – 1.4) and (as above) SO_2 exceeded its one-hour guideline at 12 locations (HI range 1.0 – 2.2). The total HI for each location exceeded 1.0 at all locations for both Case 1A (total HI range 1.6 – 5.8) and Case 2B (total HI range 1.8 – 14.0). A summary of these results is presented in Table 7.

Table 7. Summary of Exceedances of One-Hour Guidelines for Cases 1A and 2B Using 14 μg/m^3 for H_2S and COS (Assuming 80% Open Flare Destruction Efficiency)

Chemicals Exceeding Guideline	# Locations Where Guideline is Exceeded (19 total locations)	Range of Chemical HIs Associated w/Exceeded Guideline	# Locations Exceeding a **Total HI** of 1.0	Range of **Total HIs** Across All Locations
		CASE 1A		
H_2S	19	1.1 – 3.8	19	1.6 – 5.8
		CASE 2B		
H_2S	19	1.2 – 9.4		
COS	6	1.1 – 1.4	19	1.8 – 14.0
SO_2	12	1.0 – 2.2		

The results of the frequency analysis indicate that under lower-flow Case 1A conditions, assuming no supplemental propane is burned, an 80% open flare efficiency would produce between 3 and 66 exceedances per year when using 14 μg/m^3 as the H_2S guideline. If a 90% open flare efficiency is assumed, up to 30 exceedances per year would be predicted. Under Case 2B higher flow conditions, assuming the addition of supplemental propane, from 4 up to 316 exceedances per year would be predicted assuming an 80% open flare efficiency and up to 125 exceedances per year would be predicted assuming a 90% open flare efficiency. As discussed above, the same range of exceedances (i.e., ranging 1-58) of the SO_2 one-hour value would occur. The results of the frequency analysis are contained in

[6] Evaluation of the H_2S one-hour concentrations for Case 1B, lower flow (23 cfm) with supplemental propane, predicted exceedances at ten (10) locations when 14 μg/m^3 is used as the H_2S guideline with HI ranging from 0.4 to 2.2. Total HI exceeded 1.0 at fifteen (15) locations with total HI ranging from 0.6 to 3.4 (Appendix B).

Table 8; details in Appendix C. Figure 2 shows the number of hours per year that an H_2S guideline of 14 μg/m^3 is exceeded at each location under Case 2B higher flow conditions assuming both 80% and 90 % destruction efficiency. Note that the scale of Figure 2 is different from that of Figure 1. The number of hours per year that the SO_2 guideline is exceeded is the same in both figures, shown as the dark bar in both figures, and can be used as a visual yardstick. A comparison of Figure 1 and Figure 2 illustrates the several-fold increase in the number of exceedances per year across all locations if the H_2S guideline is decreased from 42 μg/m^3 to 14 μg/m^3.

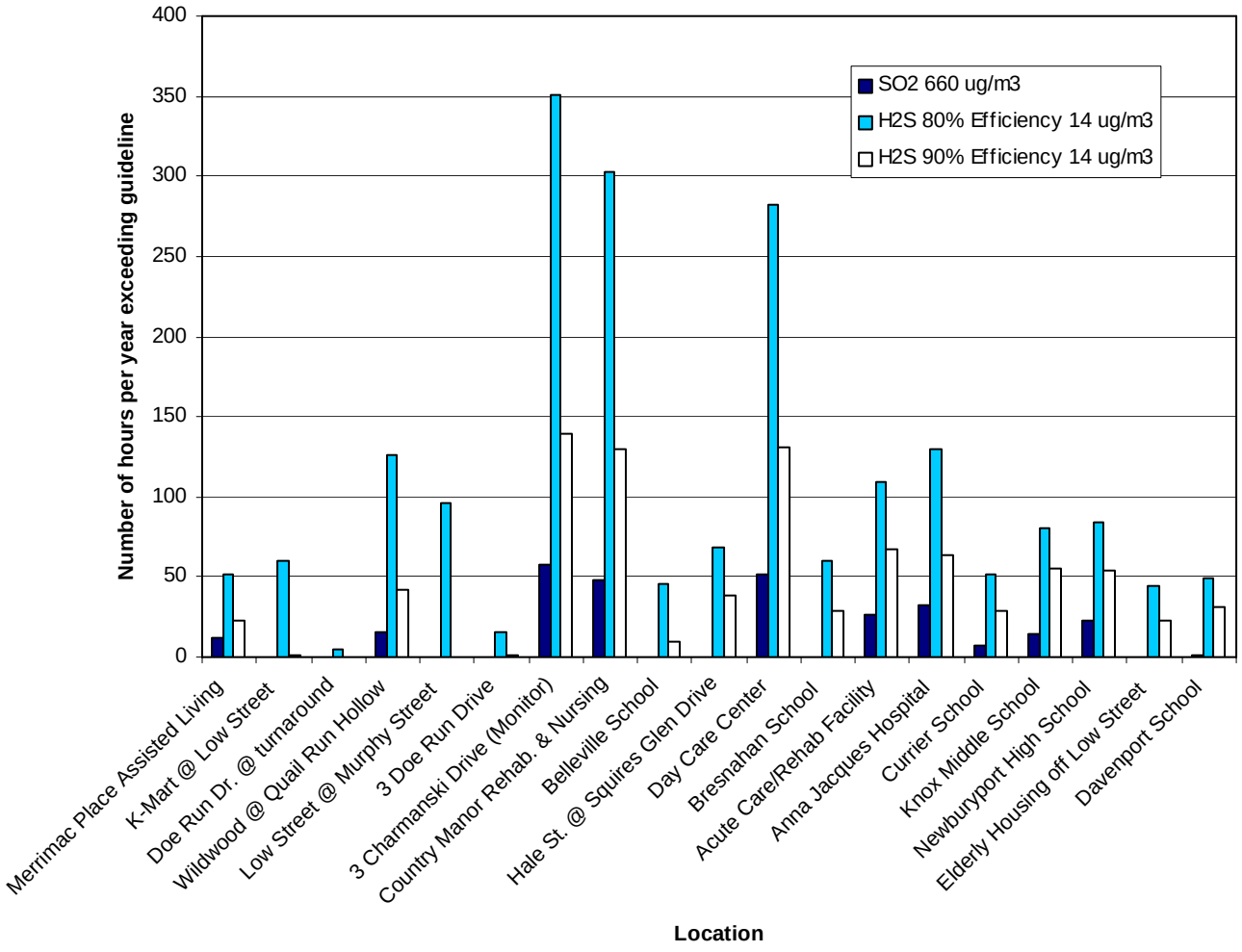
Table 8. Frequency of Predicted Exceedances of One-Hour Guideline for Cases 1A and 2B Using 14 μg/m^3 for H_2S and COS for Both 80% and 90% Destruction Efficiency

Chemical Exceeding Guideline	Range of Predicted One-Hour Exceedances per Year at 80% Open Flare Efficiency In Locations Exceeded	Range of Predicted One-Hour Exceedances per Year at 90% Open Flare Efficiency In Locations Exceeded
CASE 1A		
H_2S	3 - 66	1 - 30
CASE 2B		
H_2S	4 - 316	1 - 125
COS	1 - 22	0
SO_2	1 - 58	1 - 58

4.4 Evaluation of Predicted Annual Average Concentrations

A comparison of predicted maximum annual average concentrations to subchronic public health guidelines indicates that no individual chemical exceeds its guideline at any location for both Case 1A and Case 2B. The total subchronic HIs (considering all chemicals) for each location range from 0.12 – 1.0. Thus, no total HI at any location exceeds 1.0. The predicted annual average concentrations were compared to guidelines derived for subchronic exposure periods lasting up to seven (7) years. If exposure to landfill gas is likely to occur for more than seven (7) years, annual average concentrations should be compared to chronic guidelines that are often have lower than subchronic guidelines.

Figure 2. Case 2B High Gas Flow Rate: Frequency of Exceeding H_2S Guideline of 14 μg/m^3 and SO_2 Guideline of 660 μg/m^3:



5.0 DISCUSSION

The computer dispersion modeling exercise conducted for the Crow Lane Landfill indicates that predicted concentrations of sulfur-containing landfill gas chemicals reaching receptors in the area surrounding this facility have the potential to produce adverse health effects under a range of flow rates to the open flare assuming use of the current landfill gas management system in its present location. As the open flare flow rate increases, the number of locations affected also increases. In addition, while exceedances of the SO_2 one-hour guideline does not occur under the lower flow conditions evaluated, one-hour SO_2 concentrations are predicted to exceed the SO_2 guideline with increasing frequency as flow rates increase. The results indicate that risks associated with acute one-hour exposures are of the most concern. The highest predicted concentrations generally occurred at a residence (3 Charmanski Drive), Country Manor Rehabilitation and Nursing Center and the Day Care Center.

The computer dispersion modeling results for the 3 Charmanski Drive receptor location agree with the measured H_2S concentration data for that location from several days in August 2005 and for November – December 2005 (Table 9). In making these comparisons, it should be kept in mind that the August and November-December measurements were snapshots of conditions at the receptor location, whereas the computer dispersion model simulated concentrations over a two year period. The one-hour concentrations calculated from the measured data sets were calculated as running averages, whereas those produced by the simulation model were sequential averages.

Table 9. Comparative Measured and Modeled One-Hour Maximum H_2S Concentrations at 3 Charmanski Drive, Newburyport, MA

Type of Value	Operating Condition	Date	Maximum 1-hour Average Concentration ($\mu g/m^3$)
Measured	Raw landfill gas emission	August 5-8, 2005[a]	125.6
Measured	Higher flow flare with supplemental propane	November – December, 2005[b]	24.8
Modeled	1A	2 year simulation period	53.0
Modeled	1B	2 year simulation period	31.0
Modeled	2B	2-year simulation period	130.0

[a] taken from MassDEP (2005)
[b] taken from MassDEP (2006)

The situation experienced in August 2005 when raw, uncombusted landfill gas discharged by the active landfill gas extraction system was impacting the Charmanski Drive location was not modeled. The maximum one-hour average concentration was 125.6 $\mu g/m^3$ and the maximum individual 5-minute reading was 165.6 $\mu g/m^3$ recorded at the air monitoring station at Charmanski Drive. These values were well above both the odor thresholds discussed in this evaluation and the two health-based limits considered in this evaluation (42 $\mu g/m^3$ and 14 $\mu g/m^3$).

The situation in November and December 2005 was perhaps closest to Case 2B evaluated in this evaluation which is a higher flow rate with supplemental propane. Actual landfill gas flow rate for that period was not available. Measured values during this period were greater than the odor threshold, but between the two health-based H_2S guidelines used in this evaluation (14 $\mu g/m^3$ and 42 $\mu g/m^3$). The measured one-hour average concentrations on November-December were less than the maximum predicted under several operating scenarios (1A, 1B, 2B). Because the results from a discrete two-month period in 2005 are being compared with predicted data from a twenty-four month period, we are unable to judge whether the differences in these values represent a high prediction bias in the model, or are different due to different measurement periods.

A concentration frequency analysis for the one-hour running averages was not performed on the August or November-December data sets. Such an analysis would not be directly

comparable with the frequency analysis of the modeled data contained in this evaluation because of the two different methods of computing the hourly averages and the short duration of the measured data. It is however clear from a visual scan of the August data in the MassDEP (2005) evaluation that there were several one-hour periods on August 7 when the averages of the 12 5-minute sequential readings over sequential hours could likely have been greater than the 42 $\mu g/m^3$ health-based exposure limit (equivalent to the 30 ppb units used in that evaluation). This would have been out of approximately 63 hours of data (753 5-minute records x 5 minutes / 60 minutes per hour). If there were 2 one-hour periods, this would represent concentrations greater than the health-based exposure approximately 2/63 or 3% of the time.

Risks are mainly driven by H_2S, followed by SO_2 and COS. The remaining reduced sulfur chemicals also contribute to the total risk. In addition, due to their odorous nature, all reduced sulfur chemicals contribute to the odors associated with this facility. Note that when the open flare is out and the landfill gas control system is not operating, the ambient emissions of the sulfide chemicals and resulting concentrations from the landfill may be higher than what was predicted in this exercise. When the open flare is not operating SO_2 is not being generated by the combustion of the sulfide chemicals by the open flare.

Exceedances of the H_2S and SO_2 individual guidelines are predicted to occur under the range of flow rates modeled. As the flow rate approaches 130 cfm, the frequency with which public health guidelines are exceeded, and the number of locations at which these guidelines are exceeded also increases. See Tables C-1–C-5 in Appendix C for a summary of exceedance frequency and locations exceeded.

For H_2S, assuming an 80% open flare efficiency rate, exceedances of the H_2S guideline of 42 $\mu g/m^3$ are predicted at 3 – 15 locations within the low to high flow rate range. At a 90% open flare efficiency, there are no exceedances predicted under the lowest flow conditions. However, at a 90% efficiency at the higher flow rate, the evaluation predicts exceedances at 7 locations. In addition, if it were assumed that the threshold for odor and health effects for H_2S is lower than the 42 $\mu g/m^3$ used for this evaluation, the number of predicted exceedances of the one-hour H_2S guideline and the number of locations experiencing exceedances would be even greater.

Exceedances of the one-hour SO_2 guideline are predicted to occur under the highest flow conditions at 12 locations. Thus, the potential for the occurrence of adverse health impacts associated with exposure to sulfur chemicals from this landfill increases as the open flare flow rate approaches 130 cfm. As discussed in Section 3.2.1, an exceedance of the one-hour SO_2 guideline indicates a potential for a person with asthma to experience adverse health effects as this value was derived based on consideration of the more sensitive individuals in the population. The likelihood of a person without asthma to experience effects at this level would be lower. In addition, as discussed in Section 3.1, the predicted concentrations of SO_2 were conservatively over predicted by either 20% or 10% (corresponding to 80% and 90% open flare destruction efficiencies, respectively). However, SO_2 exceedances are still likely to occur even after adjusting for the over prediction. Despite the uncertainties inherent in these estimates, the modeling exercise illustrates the increasing potential for SO_2 to produce adverse health effects as the gas flow rate increases.

Total HIs exceed a reference value of 1.0 at 17 - 18 locations associated with the range of lower to higher flow conditions assuming an 80% open flare efficiency (Table 5). A total HI is usually calculated to sum the potential cumulative effects of chemicals acting via the same mechanism and producing similar effects. While many of the sulfur chemicals evaluated produce similar sorts of effects on the respiratory system and the central nervous system, and also contribute to the nuisance odor issue, the mechanism by which these chemicals produce their effect may differ among these chemicals. For example, at guideline levels, the effects of H_2S are directly related to the odor issue, that can trigger effects, mediated through the central nervous system, such as headache, nausea and vomiting. While it is possible that a sensitive person with asthma, who is already disposed to respiratory effects, may experience an effect on the respiratory system (e.g., bronchoconstriction), in response to this odor, the H_2S respiratory effects are mediated through the central nervous system, and are not believed to be a result of a direct action on the respiratory system. SO_2, at guideline levels, produces a direct effect on receptors within the respiratory system, leading to bronchoconstriction. Due to the differences in the way these chemicals produce their effects, the assumption that their effects are cumulative is likely an overestimate. However, total HIs were calculated as a conservative upper bound estimate of the potential for cumulative effects.

Given the acute nature of the health effects associated with exposure to reduced sulfur chemicals such as H_2S, the fact that exceedances are predicted to occur multiple times per year is of concern. Health effects including headache, nausea and throat irritation are the typical short-term effects associated with acute exposure to these chemicals. In addition, people with asthma or individuals who may already be compromised with sensitive respiratory systems or cardiovascular systems could experience more serious effects from such exposures. In the same way, an exceedance of the SO_2 guideline could be of particular concern to those with asthma or breathing difficulties. The fact that the modeling study has identified the Day Care Center and Country Manor Rehabilitation and Nursing Center among its most impacted locations is of concern as young children and the elderly represent two groups that may potentially be more sensitive to exposures to SO_2.

Finally, the results of this evaluation are consistent with the many complaints received from residents living near this landfill. The guideline used to evaluate H_2S represents a level at which both health effects and odors have been documented in studies conducted with people. The results thus indicate that, if the current operating practices continue into the future, without the removal of sulfur chemicals by pre-treatment prior to the open flare, it is likely that the incidence of both odor complaints and health complaints will continue and increase as landfill gas flow rates to the open flare are increased.

6.0 UNCERTAINTY IN THE RISK EVALUATION

All risk evaluations contain sources of uncertainty and variability that need to be considered to appropriately interpret the results. Uncertainty arises from lack of knowledge in a process and can be reduced by getting more information. Variability arises from natural

variation in processes, e.g., people are different heights, and cannot be reduced by getting more information.

Uncertainty and variability within this risk evaluation are found within the estimates of exposure and toxicity. Assumptions are made in the risk evaluation when information is lacking, and to account for known sources of variability. In general, assumptions are selected to bias the results to overestimate risk, rather than underestimate risk.

The risk evaluation uses exposure estimates based on predicted ambient air concentrations estimated using dispersion air modeling with assumptions about meteorological conditions, gas flow rate, type of control equipment, and control equipment efficiency in destroying sulfur chemicals.

The air dispersion computer model, AERMOD, with assumptions used in the model is considered biased high and intended to overestimate the predicted ambient air concentrations.

The gas flow rate at the site is variable across time on a daily basis, seasonally and over multiple years. Two gas flow rates, "lower" 23 cfm and "higher" 130 cfm, were used in the analysis to evaluate the range of risks associated with the predicted variability in gas flow rates.

The model assumes that the control equipment currently in use on the site is operating during the modeling period. The efficiency of the equipment is both uncertain and variable; two estimates of efficiency in sulfur destruction were used to evaluate the range of risks associated with operating efficiency, 80% efficiency, considered to be "worst case" operating efficiency and 90% efficiency, considered to represent a low estimate of the expected operating efficiency. In addition the model assumes that all sulfur entering the system is released as sulfur dioxide when some is released as the other sulfur chemicals. Thus, the predicted sulfur dioxide concentrations are thought to be over-estimated by 20% assuming 80% efficiency, and by 10% assuming 90% efficiency. These assumptions about operating efficiency and sulfur dioxide release were conservatively chosen to overestimate risk.

Toxicity estimates can have varying amounts of uncertainty depending on the information available for their derivation. In addition, population response following exposure to a chemical is variable, i.e., some people are more sensitive than others, and the people that make up the sensitive population for a chemical can be different for different chemicals. The guidelines available for this evaluation range from those estimated from sensitive people, e.g., sulfur dioxide acute toxicity is based on studies in volunteers with asthma exposed for the same duration evaluated in this risk evaluation, to those estimated from chemicals with similar structure, e.g., no toxicity information was located for isopropyl mercaptan for any duration, so toxicity was estimated from other mercaptans.

The uncertainty in the one-hour guidelines selected for sulfur dioxide and hydrogen sulfide is low. These guidelines were developed based on studies of people, taking into account the range of sensitivity (i.e., variability) within the population by evaluating effects in sensitive members of the population. Thus, the estimates of health risk and exceedances associated with

one-hour exposures to sulfur dioxide and hydrogen sulfide are more certain than other exposure durations.

The estimates of risk made using the individual chemical hazard index and the total hazard index are based on the single highest predicted ambient air concentration within the averaging period for each chemical at each location. This means that estimates of risk may be biased high and that risk on average over time is likely to be lower.

However, as indicated by the analysis of the number of hours per year when sulfur dioxide and hydrogen sulfide exceeded their one-hour guidelines in Figure 1, there are multiple exceedances of the one-hour guidelines. Thus, risk of adverse health effects from exposure to sulfur dioxide and hydrogen sulfide are still increased even when the predicted concentrations are lower than the maximum predicted concentration.

The total hazard index is the sum of the individual hazard indexes for all chemicals at each location, assuming that the toxicity of each chemical is additive. This assumption is uncertain, and is generally thought to bias the estimate of risk high. In this risk evaluation, the main contributors to risk, sulfur dioxide and hydrogen sulfide act through different modes of action. Thus, the total hazard index is very likely to overestimate risk.

7.0 CONCLUSIONS

The results of this modeling study concur with those reached in ORS' preliminary assessment (MassDEP, 2006a) and indicate that exceedances of individual guidelines for H_2S and SO_2 are likely occurring unless steps are taken to reduce influent concentrations of reduced sulfur chemicals to the open flare. We note that the computer dispersion modeling study indicates that if this open flare is moved to a hilltop location within the landfill, that concentrations will decrease. However, according to MassDEP engineers the installation of additional controls or pretreatment will also be necessary to reduce these emissions. The decision as to the appropriate measures to take to achieve these reductions is not within ORS' expertise and will be addressed by MassDEP NERO Bureau of Waste Prevention staff.

8.0 REFERENCES

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10.0 APPENDICES

Appendix A. Summary of Health Effects and Selection of Toxicity Guidelines
Appendix B. Spreadsheets Containing Results Of Risk Evaluation
Appendix C. Results Of Frequency Analyses
Appendix D. AALs and TELs

APPENDIX A.

SUMMARY OF HEALTH EFFECTS AND SELECTION OF TOXICITY GUIDELINES

APPENDIX A.

SUMMARY OF HEALTH EFFECTS AND SELECTION OF TOXICITY GUIDELINES

1.0 INTRODUCTION

Evaluation of potential health effects and selection of toxicity guidelines to protect public health includes consideration of exposure duration and frequency, the population potentially exposed including those that may be more sensitive, the effects of concern, the biological mechanisms of action of the chemicals, and the dose-response relationship of the chemical.

This Appendix includes a summary of potential health effects for both very short exposures, i.e., acute, and long-term exposures, i.e., subchronic and chronic, that are relevant for this analysis; the methods used to select toxicity guidelines including a description of the types of toxicity guidelines, their sources and the intended use for each value; and a summary of the specific elements considered during the selection process for each chemical.

Occupational standards were not considered relevant for this analysis, i.e., assessment of impact on exposed residential receptors including children and the elderly. Occupational standards are developed to protect workers working 40 hours per week, not exposure for 24 hours per day, 7 days per week. Workers, by definition are those that are healthy enough to work, not children, elderly or people with chronic health conditions that may be more susceptible. Occupational standards are typically set close to known effect levels, not the practice for guidelines developed for protection of public health.

2.0 SUMMARY OF HEALTH EFFECTS

Hydrogen sulfide has a pungent rotten egg odor that can be detected at very low concentrations. The ability to detect the odor of hydrogen sulfide varies among people. It is estimated that at 1.4 $\mu g/m^3$ hydrogen sulfide 6% of people can detect the odor and 1% will find it annoying, while at 14 $\mu g/m^3$ 56% of people can detect it and 17% will find it annoying (Amoore, 1985). After detecting the odor, some people may experience headaches, nausea, and irritation of eyes and nose. In one study where 10 people with asthma were exposed to 2 ppm (2800 $\mu g/m^3$) for 30 minutes, three people developed headaches and two people experienced increase airway resistance (Jappinen et al., 1990). Decreased olfactory function and neurobehavioral effects have been reported following long-term continuous exposure of workers to occupational levels of hydrogen sulfide (EPA, 2003).

Dimethyl disulfide smells like rotten cabbage and can be detected at concentrations as low as 4 $\mu g/m^3$. After detecting the odor of dimethyl disulfide, some people may experience nausea, headache or dizziness. Information on effects in people following either short- or long-term inhalation exposure is limited. Exposure of workers to high concentrations of dimethyl

disulfide and other sulfur chemicals at a pulp and paper mill was associated with slight decreases in blood enzyme levels, and increased amounts of iron and transferrin in their blood compared to workers at a facility without exposure to sulfur compounds (Klingberg et al., 1988). Results of a subchronic animal bioassay of rats exposed to 96.3 mg/m^3 (96,000 μg/m^3) for 6 hours/day, 5 days/week for 13 weeks identified hematologic effects and decreased body weight gain as sensitive responses to exposure (Kim et al., 2006). Effects observed in an animal study (Kim et al., 2006) also suggest that the hemoglobin synthesis may be affected by dimethyl disulfide.

Information on effects following exposure to dimethyl sulfide and ethyl methyl sulfide are very limited. They are expected to act similarly to dimethyl disulfide. Evaluation of single inhalation exposures to very high concentrations in rats, found that dimethyl disulfide was more toxic than dimethyl sulfide and ethyl methyl sulfide (Tansy et al., 1981; Patty's, 2000).

Methyl mercaptan has a very pungent odor, smells like rotten cabbage and can be detected at concentrations as low as 0.00004 μg/m^3 (Patty's, 2000). Information on effects in people or animals following either short- or long-term inhalation exposure is very limited. A study of workers exposed to a mixture of methyl mercaptan and other sulfur compounds, including dimethyl disulfide and dimethyl sulfide, suggests long-term exposure to high concentrations can result in changes in hemoglobin synthesis and iron metabolism (Klingberg et al., 1988). Rats exposed to 11,200 μg/m^3 methyl mercaptan by inhalation for 3 months had decreased body weight gain; no measures of hemoglobin synthesis or iron metabolism were included in the study (Tansy et al., 1981).

Information on effects following exposure to ethyl mercaptan, isopropyl mercaptan and t-butyl mercaptan are more limited than for methyl mercaptan. Evaluation of single inhalation exposures to very high concentrations in rats suggests that toxicity decreased as the size of the substituent chain increases (Patty's, 2000).

Carbon disulfide has a sweet ether-like odor. Effects following short-term inhalation exposures to high concentrations of carbon disulfide include headache, garlicky breath, nausea, vomiting, diarrhea and dizziness. Workers exposed to levels greater than 3 ppm (9000 μg/m^3) for 0.5-30 years may experience neurological changes in the central and peripheral nervous system, including changes in vision, retinopathy, decreased conduction velocity of nerves in the arms and legs, and increased cholesterol, hypertension and coronary artery disease (HSDB, 2006).

Sulfur dioxide has a pungent odor. Effects following short-term inhalation exposures to concentrations of 0.5 ppm (1300 μg/m^3) for 5-minutes in sensitive individuals can include increased airway resistance and bronchoconstriction perceived as shortness of breath, wheezing, and coughing (EPA, 1982). Sensitive individuals include people with asthma; individuals not diagnosed with asthma, but with atopic disorders (e.g., allergies); people with reactive airway disease syndrome (RADS); and people with chronic obstructive pulmonary disease or cardiovascular disease (EPA, 1982). Children and the elderly may also be sensitive subgroups. Exercise and mouth breathing increase exposure to sulfur dioxide. The bronchoconstrictive response to sulfur dioxide is very rapid and reaches its peak within 5 minutes (EPA, 1994). People are less responsive to subsequent exposures that occur within the next several hours

(EPA, 1994). Previous exposures over time periods of weeks and months do not appear to affect responses in the future, i.e., past exposures do not increase or decrease future responses (EPA, 1994). People that are not part of a sensitive subgroup are much less sensitive to the effects of sulfur dioxide.

3.0 TOXICITY GUIDELINES

Toxicity guidelines for the protection of public health were developed for acute, subchronic and chronic exposure durations. The toxicity guidelines and standards considered for use in this analysis are presented in Table A-1. The sources and definitions of the different guidelines and standards are described below along with the rationale for the selection of individual chemical- and duration-specific guideline values.

3.1 Methods for Identifying Guidelines

Reliable sources of toxicity guidelines were identified and searched for toxicity values for each of the chemicals in this analysis.

The intended use of the guidelines and standards as described by the organization that developed them was carefully reviewed to determine the relevance to this analysis.

Chemical specific guidelines were selected following evaluation of each available source and supporting documentation considering the quality, age, and relevance of the information to the specific duration of exposure. In general, toxicity guidelines for each chemical and exposure duration were selected from the available sources with priority given to the values derived by EPA, followed by MassDEP, CA EPA, ATSDR, and other sources. In some cases, studies in the primary literature were reviewed and used to derive a MassDEP provisional value.

Guidelines that are based on a minimal effect level, such as emergency response guidelines, AEGL-1 and ERPG-1, were decreased by a factor of 3 to estimate a no effect level from the minimal effect level.

Subchronic guidelines for all chemicals, except SO_2, were used as surrogate guidelines for the 24-hour averaging time. SO_2 is the only chemical in this assessment that has a 24-hour criterion value. Use of subchronic guidelines for an exposure occurring for a shorter duration is likely to overestimate the potential for health effects.

Table A-1. Acute and Subchronic Toxicity Guideline Values for the Evaluation of Computer Dispersion Modeling Results from the Crow Lane Landfill in Newburyport

Compound	Type of value	Averaging time	Concentration (ppm)	Concentration ($\mu g/m^3$)	NOAEL-equivalent (min LOAEL ÷ 3) ($\mu g/m^3$)	Toxicity Guideline Value Chosen		
						1-hr ($\mu g/m^3$)	24-hr ($\mu g/m^3$)	Subchronic ($\mu g/m^3$)
Hydrogen sulfide	AEGL 1[a]	1-hour	0.51	710[#]	240			
	CA AAQS[b]	1-hour	0.03	42		42		
	NY AAQS	1-hour	0.01	14				
	NM AAQS	1-hour	0.01	14				
	KY AAQS	1-hour	0.01	14				
	ATSDR MRL	24-hr to 14-days	0.2	280*				
	IRIS RfC[c]	subchronic	0.015	20*			20[d]	20
	ATSDR MRL	subchronic	0.02	28*				
	IRIS RfC	chronic	0.0015	2*				
Carbonyl sulfide[e]	TEEL 0	1-hr	3	7,500*	---			
					---	42	20	20
Methyl mercaptan	ERPG 1	1-hr	0.005	10[#]	3	3		
	AEGL 2[a]	1-hr	47	92,500				
	TEEL 0	1-hr	0.5	1,000*	---			
	ORS-Provisional RfC[f]	subchronic	0.0005	1*			1[d]	1
	RAIS RfC	chronic	0.001	2*	---			
Ethyl mercaptan	AEGL 1[g]	1-hr	1.0	2540[#]	850	850		
	AEGL 2[g]	1-hr	120	305,000				
	---	---	---	---	---		1[d]	1[h]
Dimethyl sulfide	ERPG 1	1-hr	0.5	1,300[#]	420	420		
	TEEL 0	1-hr	50	130,000*				
	---	---	---	---	---		11[d]	11[i]
Isopropyl mercaptan	---	---	---	---	---	850[j]		
	---	---	---	---	---		1[d]	1[h]
t-Butyl mercaptan	---	---	---	---	---	850j		
	---	---	---	---	---		1[d]	1[h]
Ethyl methyl sulfide[l]	---	---	---	---	---	420		
	---	---	---	---	---		11[d]	11

Compound	Type of value	Averaging time	Concentration (ppm)	Concentration ($\mu g/m^3$)	NOAEL-equivalent (min LOAEL ÷ 3) ($\mu g/m^3$)	Toxicity Guideline Value Chosen		
						1-hr ($\mu g/m^3$)	24-hr ($\mu g/m^3$)	Subchronic ($\mu g/m^3$)
Dimethyl disulfide	ERPG 1	1-hr	0.01	38#	13	13		
	TEEL 0	1-hr	0.01	40*	---			
	ORS-Provisional RfC[m]	subchronic	0.003	11*	---		11[d]	11
Carbon disulfide	AEGL 1[g]	1-hr	4	12,500#	4,100	4,100		
	ERPG 1	1-hr	1	3,100#	1,000			
	HEAST RfC	subchronic		700*	---		700[d]	700
	ATSDR MRL	subchronic	0.3	930*				
	IRIS RfC	chronic		700*	---			
Sulfur dioxide	AEGL 1[g]	1-hr	0.20	524#	170			
	CA AAQS	1-hr	0.25	660*	---	660		
	EPRG 1	1-hr	0.3	790#	262			
	NAAQS	24-hr	0.14	365*	---		365	
	CA AQQS	24-hour	0.04	105*	---			
	ATSDR MRL	24-hr to 14-days	0.01	26*	---			
	NAAQS	Annual	0.03	80*	---			80
	OEHHA REL	Life-time	0.25	660*	---			

These values represent mild transient Lowest Observed Adverse Effect Levels (LOAELs). An uncertainty factor of 3 was used to estimate the NOAEL.

* These values represent No Effect Adverse Levels (NOAEL)

[a] Interim AEGL value. These values have been through public review and "represent the best efforts of the National Advisory Committee for Acute Exposure Guideline Levels (NAC/AEGL) to establish exposure limits, and the values are available for use as deemed appropriate on an interim basis by federal and state regulatory agencies and the private sector." (http://www.epa.gov/oppt/aegl/process.htm) (EPA, 2006a).

[b] This value is based on the geometric mean of reported odor thresholds (CA EPA, 1999). The H_2S standard is not to be equaled or exceeded (CA EPA, 2006.

[c] A subchronic RfC was developed from the chronic RfC by removing the uncertainty factor of 10 that was used to extrapolate from the subchronic animal study.

[d] The subchronic toxicity value for this compound was adopted for this averaging period to provide a conservative estimate of toxicity in the absence of information for this shorter averaging period.

[e] Hydrogen sulfide toxicity values were adopted for carbonyl sulfide. Carbonyl sulfide is metabolized to H_2S and the toxicity is thought to be attributable to H_2S, thus H_2S toxicity values were adopted in the absence of chemical specific values.

[f] ORS-provisional value (MassDEP, 2006a).

[g] Proposed AEGL value. These values have been proposed following consensus of the National Advisory Committee for Acute Exposure Guideline Levels (NAC/AEGL) on the value and the supporting rationale. (http://www.epa.gov/oppt/aegl/process.htm) (EPA, 2006a)

[h] Methyl mercaptan subchronic toxicity value adopted for ethyl mercaptan, isopropyl mercaptan, and t-butyl mercaptan. Based on a review of the acute toxicity values for mercaptans, toxicity appears to decrease with increasing chain length; thus, use of the methyl mercaptan value should be a conservative choice for longer-chained compounds.

[l] Dimethyl disulfide subchronic toxicity value adopted for dimethyl sulfide. A comparison of the acute values of dimethyl sulfide (CH_3SCH_3) and dimethyl disulfide (CH_3SSCH_3) indicates that the disulfide is more toxic than the sulfide.

[j] Ethyl mercaptan acute toxicity value adopted for isopropyl mercaptan, and t-butyl mercaptan. Based on a review of the acute toxicity values, toxicity appears to decrease with increasing chain length; thus, use of the ethyl mercaptan value was judged to be the most appropriate choice for these longer-chained compounds.
[l] Dimethyl sulfide toxicity values for have been adopted for ethyl methyl sulfide in the absence of chemical specific data based on structural similarity.
[m] ORS-provisional value (MassDEP, 2006b).

3.2 Sources of Guidelines and Standards

Toxicity guidelines and standards were identified following review of multiple sources including,

Massachusetts Department of Environmental Protection (MassDEP);
Environmental Protection Agency (EPA);
Agency for Toxic Substances and Disease Registry (ATSDR);
California Environmental Protection Agency (CA EPA);
Risk Assessment Information System (RAIS);
World Health Organization (WHO);
American Industrial Hygiene Association (AIHA);
Department of Energy; and,
other states.

3.3 Types of Toxicity Guidelines

Toxicity guidelines are developed for different durations of exposure, ranging from acute exposures lasting from minutes up to 2 weeks, subchronic exposures lasting from 2 weeks to 7 years, and chronic exposure lasting for more than 7 years. Table A-2 presents an overview of the agency or groups that develop toxicity guidelines and standards, i.e., the sources, and the names of the guidelines and standards developed for each exposure duration. A description of the intended use and interpretation of each criterion follows the table.

Table. A-2. Overview of Ambient Air Guideline Sources and Guidelines by Exposure Duration

	Exposure Duration (Averaging Time)		
	Acute	**Subchronic**	**Chronic**
Guideline Source	**Less than 2 weeks**	**2 weeks to 7 years**	**More than 7 years**
EPA Regulatory Standard	NAAQS 1 hour, 24 hours	Annual NAAQS	Annual NAAQS
EPA NAC/AEGL	AEGL 1, 4 or 8 hours		
EPA IRIS		RfC subchronic	RfC chronic
CA EPA	AAQS, REL		REL
ATSDR	MRL 24 hours to 2 weeks	MRL intermediate	MRL chronic
AIHA	ERPG 1 hour		
DOE	TEEL 1 hour		

Glossary of terms in Table A-2

AEGLs - Acute Exposure Guideline Levels, "are intended to describe the risk to humans resulting from once-in-a-lifetime, or rare, exposure to airborne chemicals" (EPA, 2006a). Acute exposures, as defined for AEGLs, are single, non-repetitive exposures for not more than 8 hrs (EPA, 2006a). AEGLs are developed by the National Advisory Committee for Acute Exposure Guideline Level for Hazardous Substances (NAC/AEGL) following a four-step process including public review and concurrence of the NAC/AEGL committee.

AEGL-1 - the airborne concentration of a substance above which it is predicted that the general population, including susceptible individuals, could experience notable discomfort,

irritation, or certain asymptomatic nonsensory effects. However, the effects are not disabling and are transient and reversible upon cessation of exposure (EPA, 2006a).

AEGL-2 - the airborne concentration of a substance above which it is predicted that the general population, including susceptible individuals, could experience irreversible or other serious, long-lasting adverse health effects or an impaired ability to escape (EPA, 2006a).

ATSDR – Agency for Toxic Substances and Disease Registry, Centers for Disease Control, Department of Health and Human Services. ATSDR develops MRLs for acute, intermediate and chronic exposure durations.

CA AAQS - California Ambient Air Quality Standard. (CA EPA, 2006).

CA EPA – California Environmental Protection Agency. CA EPA develops RELs for acute and chronic exposure durations.

EPA – US Environmental Protection Agency. EPA develops RfCs for chronic and subchronic exposure durations, AEGLS for acute exposures, maintains IRIS and HEAST.

ERPG-1 - Emergency Response Planning Guidelines are developed by the American Industrial Hygiene Association (AIHA) to be the maximum airborne concentration below which it is believed that nearly all individuals could be exposed for up to 1 hr without experiencing other than mild transient adverse health effects or perceiving a clearly defined, objectionable odor (AIHA, 2006).

HEAST – Superfund Health Effects Assessment Summary Tables (EPA, 1997).

IRIS – Integrated Risk Information System, EPA.

MRL – Minimum Response Level – An MRL is an estimate of the daily human exposure to a hazardous substance that is likely to be without appreciable risk of adverse noncancer health effects over a specified duration of exposure (ATSDR, 2006). MRLs are developed for acute, subchronic and chronic exposure durations.

NAAQS – National Ambient Air Quality Standards are federal regulatory standards established under the Clean Air Act. One-hour and 24-hour NAAQS are not to be exceeded more than once per year. An annual NAAQS, compared to the arithmetic mean of ambient concentrations, is not to be exceeded. The primary standards are set limits intended to protect public health, including the health of "sensitive" populations such as asthmatics, children, and the elderly (EPA, 2006d).

ORS – MassDEP, Office of Research and Standards

RAIS – Risk Assessment Information System is a source of EPA provisional values. http://risk.lsd.ornl.gov/

REL – Reference Exposure Levels developed by California Environmental Protection Agency for acute and chronic durations. A REL is an airborne level of a chemical at or below which no adverse health effects are anticipated in individuals exposed to that level.

RfC – Reference Concentration. An estimate (with uncertainty spanning perhaps an order of magnitude) of a continuous inhalation exposure to the human population (including sensitive subgroups) that is likely to be without an appreciable risk of deleterious effects during a lifetime. It can be derived from a NOAEL, LOAEL, or benchmark concentration, with uncertainty factors generally applied to reflect limitations of the data used (EPA, 2006c).

TEEL-0 - Temporary Emergency Exposure Limit 0 is intended to be the threshold concentration below which most people will experience no appreciable risk of health effects (DOE, 2006). TEELs are developed using a defined hierarchy of information by the Subcommittee on Consequence Assessment and Protective Actions (SCAPA) for US Department of Energy (DOE) so that facilities could conduct appropriate hazard analyses and consequence assessments for chemicals lacking AEGLs or ERPGs.

4.0 SUMMARY OF CHEMICAL-SPECIFIC GUIDELINES SELECTED FOR THIS ANALYSIS

4.1 Hydrogen Sulfide

The California EPA 1-hour ambient air quality standard (AAQS) of 42 $\mu g/m^3$ was used as the 1-hour toxicity criterion for hydrogen sulfide in this analysis (CA EPA, 2006). The CA AAQS is based on an estimate of the mean odor threshold of a population and is a concentration where 83% of people are expected to be able to detect the odor and 40% of the population will be annoyed by the odor (CA EPA, 1999a). The CA AAQS regulations specify that the hydrogen sulfide AAQS is not to be equaled or exceeded.

Additional 1-hour guidelines are available from New York State, New Mexico, Kentucky and EPA. The New York 1-hour AAQS is 14 $\mu g/m^3$. It is intended to "prevent disagreeable odors" and is not to be exceeded more that once per year (NYS DEC Rules and Regulations, Subpart 257-10). The New Mexico 1-hour AAQS of 14 $\mu g/m^3$ is a one-hour average that is not to be exceeded more than once per year (20.2.3.110 NMAC). The Kentucky 1-hour average AAQS of 14 $\mu g/m^3$ is a secondary standard that is not to be exceeded more than once per year (401 KAR 53:010). An interim 1-hour AEGL 1 of 710 $\mu g/m^3$ is available for "use as deemed appropriate on an interim basis by federal and state regulatory agencies and the private sector (EPA, 2002; 2006b)". The interim AEGL is based on the concentration associated with a distinct level of odor awareness (EPA, 2002; Faulke, 2006).

A subchronic criterion for hydrogen sulfide is available from ATSDR. ATSDR developed an intermediate MRL of 28 $\mu g/m^3$ based on loss of olfactory neurons in rats exposed to 42,000 $\mu g/m^3$ (30 ppm) and higher for 6 hours per day, 5 days per week for 10

weeks (ATSDR, 2004). EPA has a chronic RfC of 2 μg/m^3 for hydrogen sulfide (EPA, 2003).

4.2 Carbonyl Sulfide

Hydrogen sulfide guidelines for all averaging times were adopted for carbonyl sulfide. Carbonyl sulfide is metabolized in the body into hydrogen sulfide and water (Chengelis and Neal, 1980). Health effects observed following exposure to carbonyl sulfide are thought to be due to the actions of hydrogen sulfide.

4.3 Methyl Mercaptan

The 1-hour ERPG of 10 μg/m^3 for methyl mercaptan was adjusted to a no effect level and used as the 1-hour criterion value of 3 μg/m^3 for methyl mercaptan. The other available 1-hour guidelines, the interim AEGL-2 (EPA, 2006c) and the TEEL 0 (DOE, 2005), would permit more severe health effects, or are of lower quality, respectively. An EPA provisional chronic RfC was located on the RAIS web site (RAIS, 2006), however documentation for the value was not available. ATSDR (1992) did not develop MRLs for methyl mercaptan. MassDEP developed a provisional subchronic RfC of 1 μg/m^3 for methyl mercaptan for use in this analysis (MassDEP, 2006a).

4.4 Ethyl Mercaptan

The proposed 1-hour AEGL-1 of 2540 μg/m^3 for ethyl mercaptan was adjusted to a no effect level and used as the 1-hour criterion value of 850 μg/m^3 for ethyl mercaptan (EPA, 2006b). The subchronic criterion for methyl mercaptan of 1 μg/m^3 was used as a surrogate for the ethyl mercaptan subchronic criterion.

4.5 Isopropyl Mercaptan and t-Butyl Mercaptan

No relevant toxicity guidelines were located for isopropyl mercaptan and t-butyl mercaptan. Toxicity guidelines for ethyl mercaptan were used as surrogate guidelines to estimate the potential for health effects. A review of acute toxicity values (lethal doses to animals) suggests that toxicity of the mercaptans decreases as the side chains increase in size, i.e., toxicity greatest for methyl mercaptan, then ethyl, isopropyl, and t-butyl mercaptan (Patty's, 2000).

4.6 Dimethyl Disulfide

The 1-hour ERPG of 38 μg/m^3 for dimethyl disulfide was adjusted to a no effect level and used as the 1-hour criterion value of 13 μg/m^3 for dimethyl disulfide. The 1-hour TEEL 0 value of 40 μg/m^3 is essentially the same as the 1-hour ERPG 1 (DOE, 2005). No subchronic or chronic toxicity values were located for dimethyl disulfide. Thus, MassDEP developed a provisional subchronic toxicity value of 11 μg/m^3 using a recently published subchronic bioassay (Kim et al., 2006) for this analysis (MassDEP, 2006b)

4.7 Dimethyl Sulfide

The 1-hour ERPG of 1300 μg/m^3 for dimethyl sulfide was adjusted to a no effect level and used as the 1-hour criterion value of 420 μg/m^3 for dimethyl sulfide. No subchronic or chronic toxicity values or studies that could be used to develop a subchronic toxicity value were located for dimethyl sulfide. Thus, the subchronic criterion for dimethyl disulfide was used as a surrogate for evaluating potential health effects of dimethyl sulfide.

4.8 Ethyl Methyl Sulfide

No relevant toxicity guidelines were located for ethyl methyl sulfide. Toxicity guidelines for dimethyl sulfide were used as surrogate guidelines to estimate the potential for health effects based on structural similarity.

4.9 Carbon Disulfide

The proposed 1-hour AEGL 1 of 12,500 μg/m^3 for carbon disulfide was adjusted to a no effect level and used as the 1-hour criterion value of 4100 μg/m^3 for carbon disulfide. A 1-hour ERPG at a lower concentration was available, but not selected because the AEGL is developed by a NAS committee instead of by a nongovernmental group.

Subchronic guidelines were available from EPA (EPA, 1997) and ATSDR (1996). The chronic RfC of 700 μg/m^3 based on developmental effects was adopted as the subchronic criterion by EPA (EPA, 1997) and was selected as the subchronic criterion for carbon disulfide in this analysis. The intermediate MRL developed by ATSDR is 930 μg/m^3 (ATSDR, 1996). The RfC and MRL are both derived from the same occupational study. The difference in the values is due to use of different methods for estimating the effect level for the starting point of the animal to human extrapolation, i.e., benchmark dose method (EPA) or NOAEL/LOAEL (ATSDR) method.

4.10 Sulfur Dioxide

The 1 hour ambient air quality standard of 660 μg/m^3 (0.25 ppm) developed by CA EPA was used as the 1-hour criterion for sulfur dioxide (CA EPA, 1999b; 2006). The 24-hour NAAQS of 365 μg/m^3 (0.14 ppm) and the annual NAAQS of 80 μg/m^3 (0.03 ppm) were used for the 24-hour and subchronic guidelines for sulfur dioxide, respectively (EPA, 2006d). The NAAQS values are average values over the specified time periods developed to prevent short-term peak exposures from occurring. The 1-hour average AAQS and 24-hour average NAAQS are not to be exceeded more than one time per year. The annual NAAQS is not to be exceeded. EPA staff recommended that a 1-hour NAAQS ranging from 660 μg/m^3 (0.25 ppm) to 2000 μg/m^3 (0.75 ppm) be established for sulfur dioxide (EPA, 1982). The lower end of the range "represents a 1-hour level for which the maximum 5 to 10 minute peak exposures do not exceed 0.5 ppm, which is the lowest level where potentially significant responses in free (oronasal) breathing asthmatics have been reported in the literature as of this writing"; the upper end of the range "represents concentrations at which significant

functional and symptomatic responses in exposed sensitive asthmatics and atopics appears high" (EPA, 1982). A 1-hour NAAQS has not been promulgated for sulfur dioxide.

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APPENDIX B.

SPREADSHEETS CONTAINING RESULTS OF RISK EVALUATION

Case 1 A - Current Location - 23 cfm - using 42 µg/m3 for H2S and COS - 1-hour averaging period																			
Chemicals	**Acute Tox Values**	**Anna Jacques Hospital**	**Newburyport High School**	**Davenport School**	**Currier School**	**Belleville School**	**Bresnahan School**	**Country Manor Rehab. and Nursing Ctr.**	**Elderly Housing off Low Street**	**Knox Middle School**	**Acute Care/Rehab Facility**	**Hale St. @ Squires Glen Drive**	**3 Doe Run Drive**	**Doe Run Dr. @ turnaround**	**Wildwood @ Quail Run Hollow**	**3 Charmanski Drive (Monitor)**	**Day Care Center**	**Low Street @ Murphy Street**	**K-Mart @ Low Street**	**Merrimac Place Assisted Living**
Hydrogen sulfide	42	8.0E-01	7.2E-01	5.6E-01	6.1E-01	4.9E-01	5.2E-01	1.2E+00	4.9E-01	7.0E-01	8.3E-01	4.8E-01	3.5E-01	3.8E-01	7.5E-01	1.3E+00	1.2E+00	6.7E-01	5.7E-01	7.0E-01
Carbonyl sulfide	42	1.2E-01	1.1E-01	8.5E-02	9.2E-02	7.4E-02	7.8E-02	1.8E-01	7.4E-02	1.1E-01	1.3E-01	7.2E-02	5.3E-02	5.7E-02	1.1E-01	1.9E-01	1.9E-01	1.0E-01	8.6E-02	1.1E-01
Methyl mercaptan	3	2.1E-01	1.9E-01	1.5E-01	1.6E-01	1.3E-01	1.3E-01	3.2E-01	1.3E-01	1.8E-01	2.2E-01	1.2E-01	9.2E-02	9.9E-02	1.9E-01	3.3E-01	3.2E-01	1.8E-01	1.5E-01	1.8E-01
Ethyl mercaptan	850	1.3E-03	1.2E-03	9.1E-04	1.0E-03	7.9E-04	8.4E-04	2.0E-03	8.0E-04	1.1E-03	1.4E-03	7.7E-04	5.7E-04	6.2E-04	1.2E-03	2.1E-03	2.0E-03	1.1E-03	9.3E-04	1.1E-03
Dimethyl sufide	420	5.4E-03	4.9E-03	3.8E-03	4.2E-03	3.3E-03	3.5E-03	8.3E-03	3.3E-03	4.8E-03	5.6E-03	3.2E-03	2.4E-03	2.6E-03	5.1E-03	8.6E-03	8.4E-03	4.6E-03	3.9E-03	4.8E-03
Isopropyl mercaptan	850	1.3E-03	1.1E-03	8.9E-04	9.7E-04	7.8E-04	8.2E-04	2.0E-03	7.8E-04	1.1E-03	1.3E-03	7.6E-04	5.6E-04	6.1E-04	1.2E-03	2.0E-03	2.0E-03	1.1E-03	9.1E-04	1.1E-03
t-Butyl mercaptan	850	1.3E-03	1.1E-03	8.8E-04	9.6E-04	7.6E-04	8.1E-04	1.9E-03	7.7E-04	1.1E-03	1.3E-03	7.4E-04	5.5E-04	6.0E-04	1.2E-03	2.0E-03	1.9E-03	1.1E-03	8.9E-04	1.1E-03
Ethyl methyl sulfide	420	2.7E-03	2.40E-03	1.87E-03	2.04E-03	1.63E-03	1.71E-03	4.08E-03	1.64E-03	2.33E-03	2.76E-03	1.58E-03	1.17E-03	1.27E-03	2.49E-03	4.23E-03	4.14E-03	2.24E-03	1.90E-03	2.33E-03
Dimethyl disulfide	13	1.1E-01	9.6E-02	7.5E-02	8.1E-02	6.5E-02	6.9E-02	1.6E-01	6.6E-02	9.3E-02	1.1E-01	6.3E-02	4.7E-02	5.1E-02	9.9E-02	1.7E-01	1.7E-01	9.0E-02	7.6E-02	9.3E-02
Carbon disulfide	4100	4.5E-09	4.0E-09	3.1E-09	3.4E-09	2.7E-09	2.9E-09	6.8E-09	2.7E-09	3.9E-09	4.6E-09	2.6E-09	2.0E-09	2.1E-09	4.2E-09	7.1E-09	6.9E-09	3.8E-09	3.2E-09	3.9E-09
Sulfur dioxide	660	5.7E-01	5.1E-01	4.0E-01	4.4E-01	3.5E-01	3.7E-01	8.8E-01	3.5E-01	5.0E-01	5.9E-01	3.4E-01	2.5E-01	2.7E-01	5.3E-01	9.1E-01	8.9E-01	4.8E-01	4.1E-01	5.0E-01
Number of Individual HI > 1.0:		0	0	0	0	0	0	1	0	0	0	0	0	0	0	1	1	0	0	0
	Total HI:	**1.8E+00**	**1.6E+00**	**1.3E+00**	**1.4E+00**	**1.1E+00**	**1.2E+00**	**2.8E+00**	**1.1E+00**	**1.6E+00**	**1.9E+00**	**1.1E+00**	**8.0E-01**	**8.7E-01**	**1.7E+00**	**2.9E+00**	**2.8E+00**	**1.5E+00**	**1.3E+00**	**1.6E+00**

Locations with Total HI > 1.0:

Anna Jacques Hospital
Newburyport High School
Davenport School
Currier School
Belleville School
Bresnahan School
Country Manor Rehab. and Nursing Ctr.
Elderly Housing off Low Street
Knox Middle School
Acute Care/Rehab Facility
Hale St. @ Squires Glen Drive

Wildwood @ Quail Run Hollow
3 Charmanski Drive (Monitor)
Day Care Center
Low Street @ Murphy Street
K-Mart @ Low Street
Merrimac Place Assisted Living

Case 1B - Current Location - 23 cfm - with supplemental propane - using 42 µg/m3 for H2S and COS - 1-hour averaging period																				
Chemicals	**Acute Tox Values**	**Anna Jacques Hospital**	**Newburyport High School**	**Davenport School**	**Currier School**	**Belleville School**	**Bresnahan School**	**Country Manor Rehab. and Nursing Ctr.**	**Elderly Housing off Low Street**	**Knox Middle School**	**Acute Care/Rehab Facility**	**Hale St. @ Squires Glen Drive**	**3 Doe Run Drive**	**Doe Run Dr. @ turnaround**	**Wildwood @ Quail Run Hollow**	**3 Charmanski Drive (Monitor)**	**Day Care Center**	**Low Street @ Murphy Street**	**K-Mart @ Low Street**	**Merrimac Place Assisted Living**
Hydrogen sulfide	42	5.4E-01	4.6E-01	3.4E-01	3.7E-01	2.9E-01	3.2E-01	6.9E-01	3.0E-01	4.4E-01	5.3E-01	3.0E-01	1.7E-01	1.2E-01	5.3E-01	7.2E-01	7.4E-01	2.2E-01	1.9E-01	5.3E-01
Carbonyl sulfide	42	8.1E-02	6.9E-02	5.1E-02	5.5E-02	4.3E-02	4.8E-02	1.0E-01	4.6E-02	6.7E-02	8.0E-02	4.5E-02	2.6E-02	1.9E-02	7.9E-02	1.1E-01	1.1E-01	3.3E-02	2.9E-02	7.9E-02
Methyl mercaptan	3	1.4E-01	1.2E-01	8.7E-02	9.5E-02	7.4E-02	8.4E-02	1.8E-01	7.9E-02	1.2E-01	1.4E-01	7.8E-02	4.5E-02	3.2E-02	1.4E-01	1.9E-01	1.9E-01	5.6E-02	5.1E-02	1.4E-01
Ethyl mercaptan	850	8.7E-04	7.4E-04	5.5E-04	5.9E-04	4.6E-04	5.2E-04	1.1E-03	4.9E-04	7.2E-04	8.6E-04	4.9E-04	2.8E-04	2.0E-04	8.6E-04	1.2E-03	1.2E-03	3.5E-04	3.2E-04	8.6E-04
Dimethyl sufide	420	3.6E-03	3.1E-03	2.3E-03	2.5E-03	1.9E-03	2.2E-03	4.7E-03	2.1E-03	3.0E-03	3.6E-03	2.0E-03	1.2E-03	8.4E-04	3.6E-03	4.9E-03	5.0E-03	1.5E-03	1.3E-03	3.6E-03
Isopropyl mercaptan	850	8.5E-04	7.2E-04	5.3E-04	5.8E-04	4.5E-04	5.1E-04	1.1E-03	4.8E-04	7.1E-04	8.4E-04	4.7E-04	2.7E-04	2.0E-04	8.4E-04	1.2E-03	1.2E-03	3.4E-04	3.1E-04	8.4E-04
t-Butyl mercaptan	850	8.4E-04	7.1E-04	5.2E-04	5.7E-04	4.5E-04	5.0E-04	1.1E-03	4.7E-04	7.0E-04	8.3E-04	4.7E-04	2.7E-04	1.9E-04	8.2E-04	1.1E-03	1.2E-03	3.4E-04	3.0E-04	8.2E-04
Ethyl methyl sulfide	420	1.79E-03	1.52E-03	1.12E-03	1.22E-03	9.50E-04	1.07E-03	2.29E-03	1.01E-03	1.48E-03	1.76E-03	9.94E-04	5.73E-04	4.14E-04	1.75E-03	2.41E-03	2.47E-03	7.21E-04	6.46E-04	1.75E-03
Dimethyl disulfide	13	7.1E-02	6.1E-02	4.5E-02	4.9E-02	3.8E-02	4.3E-02	9.1E-02	4.0E-02	5.9E-02	7.1E-02	4.0E-02	2.3E-02	1.7E-02	7.0E-02	9.6E-02	9.9E-02	2.9E-02	2.6E-02	7.0E-02
Carbon disulfide	4100	3.0E-09	2.5E-09	1.9E-09	2.0E-09	1.6E-09	1.8E-09	3.8E-09	1.7E-09	2.5E-09	3.0E-09	1.7E-09	9.6E-10	6.9E-10	2.9E-09	4.0E-09	4.1E-09	1.2E-09	1.1E-09	2.9E-09
Sulfur dioxide	660	3.8E-01	3.3E-01	2.4E-01	2.6E-01	2.0E-01	2.3E-01	4.9E-01	2.2E-01	3.2E-01	3.8E-01	2.1E-01	1.2E-01	8.9E-02	3.8E-01	5.2E-01	5.3E-01	1.5E-01	1.4E-01	3.8E-01
Number of Individual HI > 1.0:		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Total HI:	**1.2E+00**	**1.0E+00**	**7.6E-01**	**8.3E-01**	**6.5E-01**	**7.3E-01**	**1.6E+00**	**6.9E-01**	**1.0E+00**	**1.2E+00**	**6.8E-01**	**3.9E-01**	**2.8E-01**	**1.2E+00**	**1.6E+00**	**1.7E+00**	**4.9E-01**	**4.4E-01**	**1.2E+00**

Locations with Total HI > 1.0:

Anna Jacques Hospital
Newburyport High School

Country Manor Rehab. and Nursing Ctr.

Knox Middle School
Acute Care/Rehab Facility

Wildwood @ Quail Run Hollow
3 Charmanski Drive (Monitor)
Day Care Center

Merrimac Place Assisted Living

Case 2A - Current Location - 130 cfm - using 42 µg/m3 for H2S and COS - 1-hour averaging period																			
Chemicals	**Acute Tox Values**	**Anna Jacques Hospital**	**Newburyport High School**	**Davenport School**	**Currier School**	**Belleville School**	**Bresnahan School**	**Country Manor Rehab. and Nursing Ctr.**	**Elderly Housing off Low Street**	**Knox Middle School**	**Acute Care/Rehab Facility**	**Hale St. @ Squires Glen Drive**	**3 Doe Run Drive**	**Doe Run Dr. @ turnaround**	**Wildwood @ Quail Run Hollow**	**3 Charmanski Drive (Monitor)**	**Day Care Center**	**Low Street @ Murphy Street**	**K-Mart @ Low Street**	**Merrimac Place Assisted Living**
Hydrogen sulfide	42	2.7E+00	2.3E+00	1.7E+00	1.8E+00	1.4E+00	1.6E+00	3.4E+00	1.5E+00	2.2E+00	2.6E+00	1.5E+00	9.2E-01	5.8E-01	2.7E+00	3.6E+00	3.7E+00	9.1E-01	1.0E+00	2.7E+00
Carbonyl sulfide	42	4.1E-01	3.4E-01	2.5E-01	2.8E-01	2.1E-01	2.5E-01	5.1E-01	2.2E-01	3.3E-01	3.9E-01	2.2E-01	1.4E-01	8.8E-02	4.1E-01	5.4E-01	5.5E-01	1.4E-01	1.6E-01	4.1E-01
Methyl mercaptan	3	7.0E-01	5.9E-01	4.4E-01	4.8E-01	3.6E-01	4.2E-01	8.9E-01	3.9E-01	5.7E-01	6.8E-01	3.8E-01	2.4E-01	1.5E-01	7.0E-01	9.4E-01	9.5E-01	2.4E-01	2.7E-01	7.1E-01
Ethyl mercaptan	850	4.4E-03	3.7E-03	2.7E-03	3.0E-03	2.3E-03	2.7E-03	5.5E-03	2.4E-03	3.5E-03	4.2E-03	2.4E-03	1.5E-03	9.5E-04	4.4E-03	5.9E-03	5.9E-03	1.5E-03	1.7E-03	4.5E-03
Dimethyl sufide	420	1.8E-02	1.5E-02	1.1E-02	1.2E-02	9.5E-03	1.1E-02	2.3E-02	1.0E-02	1.5E-02	1.8E-02	1.0E-02	6.2E-03	3.9E-03	1.8E-02	2.5E-02	2.5E-02	6.2E-03	7.0E-03	1.9E-02
Isopropyl mercaptan	850	4.3E-03	3.6E-03	2.7E-03	2.9E-03	2.2E-03	2.6E-03	5.4E-03	2.4E-03	3.5E-03	4.1E-03	2.3E-03	1.5E-03	9.3E-04	4.3E-03	5.7E-03	5.8E-03	1.4E-03	1.6E-03	4.4E-03
t-Butyl mercaptan	850	4.2E-03	3.5E-03	2.6E-03	2.9E-03	2.2E-03	2.5E-03	5.3E-03	2.3E-03	3.4E-03	4.1E-03	2.3E-03	1.4E-03	9.1E-04	4.2E-03	5.7E-03	5.7E-03	1.4E-03	1.6E-03	4.3E-03
Ethyl methyl sulfide	420	8.95E-03	7.55E-03	5.56E-03	6.12E-03	4.66E-03	5.42E-03	1.13E-02	4.93E-03	7.24E-03	8.65E-03	4.91E-03	3.06E-03	1.94E-03	8.97E-03	1.20E-02	1.22E-02	3.03E-03	3.44E-03	9.13E-03
Dimethyl disulfide	13	3.6E-01	3.0E-01	2.2E-01	2.4E-01	1.9E-01	2.2E-01	4.5E-01	2.0E-01	2.9E-01	3.5E-01	2.0E-01	1.2E-01	7.7E-02	3.6E-01	4.8E-01	4.9E-01	1.2E-01	1.4E-01	3.6E-01
Carbon disulfide	4100	1.5E-08	1.3E-08	9.3E-09	1.0E-08	7.8E-09	9.1E-09	1.9E-08	8.2E-09	1.2E-08	1.4E-08	8.2E-09	5.1E-09	3.2E-09	1.5E-08	2.0E-08	2.0E-08	5.1E-09	5.8E-09	1.5E-08
Sulfur dioxide	660	1.9E+00	1.6E+00	1.2E+00	1.3E+00	1.0E+00	1.2E+00	2.4E+00	1.1E+00	1.6E+00	1.9E+00	1.1E+00	6.6E-01	4.2E-01	1.9E+00	2.6E+00	2.6E+00	6.5E-01	7.4E-01	2.0E+00
Number of Individual HI > 1.0:		2	2	2	2	1	2	2	2	2	2	2	0	0	2	2	2	0	1	2
	Total HI:	**6.1E+00**	**5.2E+00**	**3.8E+00**	**4.2E+00**	**3.2E+00**	**3.7E+00**	**7.7E+00**	**3.4E+00**	**4.9E+00**	**5.9E+00**	**3.4E+00**	**2.1E+00**	**1.3E+00**	**6.1E+00**	**8.2E+00**	**8.3E+00**	**2.1E+00**	**2.4E+00**	**6.2E+00**

Locations with Total HI > 1.0:

Anna Jacques Hospital
Newburyport High School
Davenport School
Currier School
Belleville School
Bresnahan School
Country Manor Rehab. and Nursing Ctr.
Elderly Housing off Low Street
Knox Middle School
Acute Care/Rehab Facility
Hale St. @ Squires Glen Drive
3 Doe Run Drive
Doe Run Dr. @ turnaround
Wildwood @ Quail Run Hollow
3 Charmanski Drive (Monitor)
Day Care Center
Low Street @ Murphy Street
K-Mart @ Low Street
Merrimac Place Assisted Living

Case 2B - Current Location - 130 cfm - with supplemental propane - using 42 µg/m3 for H2S and COS - 1-hour averaging period																			
Chemicals	**Acute Tox Values**	**Anna Jacques Hospital**	**Newburyport High School**	**Davenport School**	**Currier School**	**Belleville School**	**Bresnahan School**	**Country Manor Rehab. and Nursing Ctr.**	**Elderly Housing off Low Street**	**Knox Middle School**	**Acute Care/Rehab Facility**	**Hale St. @ Squires Glen Drive**	**3 Doe Run Drive**	**Doe Run Dr. @ turnaround**	**Wildwood @ Quail Run Hollow**	**3 Charmanski Drive (Monitor)**	**Day Care Center**	**Low Street @ Murphy Street**	**K-Mart @ Low Street**	**Merrimac Place Assisted Living**
Hydrogen sulfide	42	2.3E+00	1.9E+00	1.4E+00	1.6E+00	1.2E+00	1.4E+00	2.9E+00	1.2E+00	1.8E+00	2.2E+00	1.2E+00	8.5E-01	3.9E-01	2.4E+00	3.1E+00	3.1E+00	6.4E-01	9.5E-01	2.5E+00
Carbonyl sulfide	42	3.5E-01	2.9E-01	2.1E-01	2.4E-01	1.8E-01	2.1E-01	4.3E-01	1.9E-01	2.8E-01	3.3E-01	1.9E-01	1.3E-01	5.9E-02	3.6E-01	4.6E-01	4.7E-01	9.6E-02	1.4E-01	3.7E-01
Methyl mercaptan	3	6.1E-01	5.0E-01	3.7E-01	4.1E-01	3.0E-01	3.7E-01	7.5E-01	3.2E-01	4.8E-01	5.6E-01	3.2E-01	2.2E-01	1.0E-01	6.2E-01	8.0E-01	8.1E-01	1.7E-01	2.5E-01	6.4E-01
Ethyl mercaptan	850	3.8E-03	3.1E-03	2.3E-03	2.6E-03	1.9E-03	2.3E-03	4.7E-03	2.0E-03	3.0E-03	3.5E-03	2.0E-03	1.4E-03	6.3E-04	3.9E-03	5.0E-03	5.1E-03	1.0E-03	1.6E-03	4.0E-03
Dimethyl sufide	420	1.6E-02	1.3E-02	9.6E-03	1.1E-02	7.9E-03	9.7E-03	1.9E-02	8.3E-03	1.2E-02	1.5E-02	8.4E-03	5.7E-03	2.6E-03	1.6E-02	2.1E-02	2.1E-02	4.3E-03	6.5E-03	1.7E-02
Isopropyl mercaptan	850	3.7E-03	3.1E-03	2.3E-03	2.5E-03	1.9E-03	2.3E-03	4.6E-03	2.0E-03	2.9E-03	3.4E-03	2.0E-03	1.3E-03	6.2E-04	3.8E-03	4.9E-03	5.0E-03	1.0E-03	1.5E-03	3.9E-03
t-Butyl mercaptan	850	3.7E-03	3.0E-03	2.2E-03	2.5E-03	1.8E-03	2.2E-03	4.5E-03	1.9E-03	2.9E-03	3.4E-03	1.9E-03	1.3E-03	6.1E-04	3.7E-03	4.8E-03	4.9E-03	1.0E-03	1.5E-03	3.9E-03
Ethyl methyl sulfide	420	7.81E-03	6.40E-03	4.72E-03	5.28E-03	3.88E-03	4.74E-03	9.56E-03	4.09E-03	6.09E-03	7.21E-03	4.14E-03	2.82E-03	1.30E-03	7.89E-03	1.02E-02	1.04E-02	2.12E-03	3.18E-03	8.20E-03
Dimethyl disulfide	13	3.1E-01	2.6E-01	1.9E-01	2.1E-01	1.6E-01	1.9E-01	3.8E-01	1.6E-01	2.4E-01	2.9E-01	1.7E-01	1.1E-01	5.2E-02	3.2E-01	4.1E-01	4.2E-01	8.5E-02	1.3E-01	3.3E-01
Carbon disulfide	4100	1.3E-08	1.1E-08	7.9E-09	8.8E-09	6.5E-09	7.9E-09	1.6E-08	6.8E-09	1.0E-08	1.2E-08	6.9E-09	4.7E-09	2.2E-09	1.3E-08	1.7E-08	1.7E-08	3.5E-09	5.3E-09	1.4E-08
Sulfur dioxide	660	1.7E+00	1.4E+00	1.0E+00	1.1E+00	8.3E-01	1.0E+00	2.1E+00	8.8E-01	1.3E+00	1.5E+00	8.9E-01	6.0E-01	2.8E-01	1.7E+00	2.2E+00	2.2E+00	4.5E-01	6.8E-01	1.8E+00
Number of Individual HI > 1.0:		2	2	2	2	1	2	2	1	2	2	1	0	0	2	2	2	0	0	2
	Total HI:	**5.3E+00**	**4.4E+00**	**3.2E+00**	**3.6E+00**	**2.7E+00**	**3.2E+00**	**6.5E+00**	**2.8E+00**	**4.2E+00**	**4.9E+00**	**2.8E+00**	**1.9E+00**	**8.9E-01**	**5.4E+00**	**7.0E+00**	**7.1E+00**	**1.4E+00**	**2.2E+00**	**5.6E+00**

Locations with Total HI > 1.0:

Anna Jacques Hospital
Newburyport High School
Davenport School
Currier School
Belleville School
Bresnahan School
Country Manor Rehab. and Nursing Ctr.
Elderly Housing off Low Street
Knox Middle School
Acute Care/Rehab Facility
Hale St. @ Squires Glen Drive
3 Doe Run Drive

Wildwood @ Quail Run Hollow
3 Charmanski Drive (Monitor)
Day Care Center
Low Street @ Murphy Street
K-Mart @ Low Street
Merrimac Place Assisted Living

Case 2A - Top of Hill - 130 cfm - using 42 µg/m3 for H2S and COS - 1-hour averaging period																				
Chemicals	**Acute Tox Values**	**Anna Jacques Hospital**	**Newburyport High School**	**Davenport School**	**Currier School**	**Belleville School**	**Bresnahan School**	**Country Manor Rehab. and Nursing Ctr.**	**Elderly Housing off Low Street**	**Knox Middle School**	**Acute Care/Rehab Facility**	**Hale St. @ Squires Glen Drive**	**3 Doe Run Drive**	**Doe Run Dr. @ turnaround**	**Wildwood @ Quail Run Hollow**	**3 Charmanski Drive (Monitor)**	**Day Care Center**	**Low Street @ Murphy Street**	**K-Mart @ Low Street**	**Merrimac Place Assisted Living**
Hydrogen sulfide	42	1.2E-01	1.0E-01	5.2E-02	7.2E-02	7.9E-02	7.5E-02	1.2E-01	6.6E-02	1.1E-01	8.9E-02	1.5E-01	1.1E-01	1.0E-01	1.8E-01	2.3E-01	1.7E-01	1.4E-01	1.3E-01	1.7E-01
Carbonyl sulfide	42	1.8E-02	1.5E-02	7.8E-03	1.1E-02	1.2E-02	1.1E-02	1.9E-02	9.9E-03	1.6E-02	1.3E-02	2.3E-02	1.7E-02	1.5E-02	2.7E-02	3.5E-02	2.6E-02	2.2E-02	2.0E-02	2.5E-02
Methyl mercaptan	3	3.1E-02	2.6E-02	1.4E-02	1.9E-02	2.0E-02	2.0E-02	3.2E-02	1.7E-02	2.7E-02	2.3E-02	3.9E-02	3.0E-02	2.7E-02	4.6E-02	6.0E-02	4.4E-02	3.7E-02	3.4E-02	4.3E-02
Ethyl mercaptan	850	1.9E-04	1.6E-04	8.5E-05	1.2E-04	1.3E-04	1.2E-04	2.0E-04	1.1E-04	1.7E-04	1.5E-04	2.4E-04	1.9E-04	1.7E-04	2.9E-04	3.7E-04	2.8E-04	2.3E-04	2.1E-04	2.7E-04
Dimethyl sufide	420	8.0E-04	6.8E-04	3.5E-04	4.9E-04	5.3E-04	5.1E-04	8.4E-04	4.5E-04	7.1E-04	6.1E-04	1.0E-03	7.8E-04	7.0E-04	1.2E-03	1.6E-03	1.2E-03	9.7E-04	8.9E-04	1.1E-03
Isopropyl mercaptan	850	1.9E-04	1.6E-04	8.3E-05	1.1E-04	1.2E-04	1.2E-04	2.0E-04	1.0E-04	1.7E-04	1.4E-04	2.4E-04	1.8E-04	1.6E-04	2.8E-04	3.7E-04	2.7E-04	2.3E-04	2.1E-04	2.6E-04
t-Butyl mercaptan	850	1.8E-04	1.6E-04	8.1E-05	1.1E-04	1.2E-04	1.2E-04	1.9E-04	1.0E-04	1.6E-04	1.4E-04	2.4E-04	1.8E-04	1.6E-04	2.8E-04	3.6E-04	2.7E-04	2.2E-04	2.1E-04	2.6E-04
Ethyl methyl sulfide	420	3.93E-04	3.32E-04	1.73E-04	2.40E-04	2.61E-04	2.49E-04	4.14E-04	2.20E-04	3.50E-04	2.98E-04	5.00E-04	3.80E-04	3.41E-04	5.94E-04	7.65E-04	5.67E-04	4.78E-04	4.36E-04	5.49E-04
Dimethyl disulfide	13	1.6E-02	1.3E-02	6.9E-03	9.6E-03	1.0E-02	1.0E-02	1.7E-02	8.8E-03	1.4E-02	1.2E-02	2.0E-02	1.5E-02	1.4E-02	2.4E-02	3.1E-02	2.3E-02	1.9E-02	1.7E-02	2.2E-02
Carbon disulfide	4100	6.6E-10	5.6E-10	2.9E-10	4.0E-10	4.4E-10	4.2E-10	6.9E-10	3.7E-10	5.9E-10	5.0E-10	8.4E-10	6.4E-10	5.7E-10	9.9E-10	1.3E-09	9.5E-10	8.0E-10	7.3E-10	9.2E-10
Sulfur dioxide	660	8.4E-02	7.1E-02	3.7E-02	5.2E-02	5.6E-02	5.3E-02	8.9E-02	4.7E-02	7.5E-02	6.4E-02	1.1E-01	8.2E-02	7.3E-02	1.3E-01	1.6E-01	1.2E-01	1.0E-01	9.4E-02	1.2E-01
Number of Individual HI > 1.0:		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Total HI:	**2.7E-01**	**2.3E-01**	**1.2E-01**	**1.6E-01**	**1.8E-01**	**1.7E-01**	**2.8E-01**	**1.5E-01**	**2.4E-01**	**2.0E-01**	**3.4E-01**	**2.6E-01**	**2.3E-01**	**4.1E-01**	**5.2E-01**	**3.9E-01**	**3.3E-01**	**3.0E-01**	**3.7E-01**

Locations with Total HI > 1.0:

Case 2B - Top of Hill - 130 cfm - with supplemental propane - using 42 µg/m3 for H2S and COS - 1-hour averaging period																				
Chemicals	**Acute Tox Values**	**Anna Jacques Hospital**	**Newburyport High School**	**Davenport School**	**Currier School**	**Belleville School**	**Bresnahan School**	**Country Manor Rehab. and Nursing Ctr.**	**Elderly Housing off Low Street**	**Knox Middle School**	**Acute Care/Rehab Facility**	**Hale St. @ Squires Glen Drive**	**3 Doe Run Drive**	**Doe Run Dr. @ turnaround**	**Wildwood @ Quail Run Hollow**	**3 Charmanski Drive (Monitor)**	**Day Care Center**	**Low Street @ Murphy Street**	**K-Mart @ Low Street**	**Merrimac Place Assisted Living**
Hydrogen sulfide	42	1.1E-01	9.0E-02	4.7E-02	6.7E-02	7.2E-02	6.7E-02	1.1E-01	5.8E-02	9.2E-02	8.0E-02	1.4E-01	1.0E-01	9.4E-02	1.7E-01	2.1E-01	1.5E-01	1.3E-01	1.2E-01	1.6E-01
Carbonyl sulfide	42	1.6E-02	1.3E-02	7.0E-03	1.0E-02	1.1E-02	1.0E-02	1.7E-02	8.7E-03	1.4E-02	1.2E-02	2.1E-02	1.5E-02	1.4E-02	2.6E-02	3.2E-02	2.3E-02	2.0E-02	1.8E-02	2.4E-02
Methyl mercaptan	3	2.8E-02	2.3E-02	1.2E-02	1.7E-02	1.9E-02	1.7E-02	2.9E-02	1.5E-02	2.4E-02	2.1E-02	3.6E-02	2.7E-02	2.5E-02	4.4E-02	5.5E-02	3.9E-02	3.5E-02	3.1E-02	4.1E-02
Ethyl mercaptan	850	1.8E-04	1.5E-04	7.6E-05	1.1E-04	1.2E-04	1.1E-04	1.8E-04	9.4E-05	1.5E-04	1.3E-04	2.2E-04	1.7E-04	1.5E-04	2.8E-04	3.5E-04	2.4E-04	2.2E-04	1.9E-04	2.6E-04
Dimethyl sufide	420	7.3E-04	6.1E-04	3.2E-04	4.5E-04	4.9E-04	4.5E-04	7.6E-04	3.9E-04	6.2E-04	5.4E-04	9.3E-04	7.0E-04	6.4E-04	1.2E-03	1.4E-03	1.0E-03	9.1E-04	8.0E-04	1.1E-03
Isopropyl mercaptan	850	1.7E-04	1.4E-04	7.4E-05	1.1E-04	1.1E-04	1.1E-04	1.8E-04	9.2E-05	1.5E-04	1.3E-04	2.2E-04	1.6E-04	1.5E-04	2.7E-04	3.4E-04	2.4E-04	2.1E-04	1.9E-04	2.5E-04
t-Butyl mercaptan	850	1.7E-04	1.4E-04	7.3E-05	1.0E-04	1.1E-04	1.0E-04	1.8E-04	9.0E-05	1.4E-04	1.2E-04	2.1E-04	1.6E-04	1.5E-04	2.7E-04	3.3E-04	2.3E-04	2.1E-04	1.8E-04	2.5E-04
Ethyl methyl sulfide	420	3.59E-04	2.98E-04	1.55E-04	2.23E-04	2.39E-04	2.22E-04	3.73E-04	1.92E-04	3.05E-04	2.65E-04	4.55E-04	3.42E-04	3.13E-04	5.67E-04	7.06E-04	4.98E-04	4.46E-04	3.91E-04	5.25E-04
Dimethyl disulfide	13	1.4E-02	1.2E-02	6.2E-03	8.9E-03	9.6E-03	8.9E-03	1.5E-02	7.7E-03	1.2E-02	1.1E-02	1.8E-02	1.4E-02	1.3E-02	2.3E-02	2.8E-02	2.0E-02	1.8E-02	1.6E-02	2.1E-02
Carbon disulfide	4100	6.0E-10	5.0E-10	2.6E-10	3.7E-10	4.0E-10	3.7E-10	6.2E-10	3.2E-10	5.1E-10	4.4E-10	7.6E-10	5.7E-10	5.2E-10	9.5E-10	1.2E-09	8.3E-10	7.5E-10	6.5E-10	8.8E-10
Sulfur dioxide	660	7.7E-02	6.4E-02	3.3E-02	4.8E-02	5.1E-02	4.8E-02	8.0E-02	4.1E-02	6.5E-02	5.7E-02	9.7E-02	7.3E-02	6.7E-02	1.2E-01	1.5E-01	1.1E-01	9.6E-02	8.4E-02	1.1E-01
Number of Individual HI > 1.0:		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Total HI:	**2.5E-01**	**2.0E-01**	**1.1E-01**	**1.5E-01**	**1.6E-01**	**1.5E-01**	**2.5E-01**	**1.3E-01**	**2.1E-01**	**1.8E-01**	**3.1E-01**	**2.3E-01**	**2.1E-01**	**3.9E-01**	**4.8E-01**	**3.4E-01**	**3.0E-01**	**2.7E-01**	**3.6E-01**

Locations with Total HI > 1.0:

Case 1 A - Current Location - 23 cfm - 24-hour averaging period																				
Chemicals	**Acute Tox Values**	**Anna Jacques Hospital**	**Newburyport High School**	**Davenport School**	**Currier School**	**Belleville School**	**Bresnahan School**	**Country Manor Rehab. and Nursing Ctr.**	**Elderly Housing off Low Street**	**Knox Middle School**	**Acute Care/Rehab Facility**	**Hale St. @ Squires Glen Drive**	**3 Doe Run Drive**	**Doe Run Dr. @ turnaround**	**Wildwood @ Quail Run Hollow**	**3 Charmanski Drive (Monitor)**	**Day Care Center**	**Low Street @ Murphy Street**	**K-Mart @ Low Street**	**Merrimac Place Assisted Living**
Hydrogen sulfide	20	2.1E-01	1.7E-01	1.2E-01	9.4E-02	7.3E-02	1.1E-01	2.7E-01	1.3E-01	1.8E-01	1.8E-01	1.3E-01	6.9E-02	8.8E-02	1.3E-01	2.9E-01	3.9E-01	1.4E-01	1.2E-01	1.0E-01
Carbonyl sulfide	20	3.2E-02	2.6E-02	1.7E-02	1.4E-02	1.1E-02	1.7E-02	4.1E-02	2.0E-02	2.7E-02	2.6E-02	2.0E-02	1.0E-02	1.3E-02	2.0E-02	4.3E-02	5.9E-02	2.2E-02	1.9E-02	1.6E-02
Methyl mercaptan	1	7.9E-02	6.4E-02	4.3E-02	3.5E-02	2.7E-02	4.3E-02	1.0E-01	4.8E-02	6.8E-02	6.5E-02	4.9E-02	2.6E-02	3.3E-02	4.9E-02	1.1E-01	1.5E-01	5.4E-02	4.6E-02	3.8E-02
Ethyl mercaptan	1	1.4E-01	1.1E-01	7.6E-02	6.2E-02	4.8E-02	7.6E-02	1.8E-01	8.5E-02	1.2E-01	1.2E-01	8.7E-02	4.5E-02	5.8E-02	8.7E-02	1.9E-01	2.6E-01	9.5E-02	8.1E-02	6.8E-02
Dimethyl sufide	11	2.6E-02	2.1E-02	1.4E-02	1.2E-02	9.0E-03	1.4E-02	3.4E-02	1.6E-02	2.2E-02	2.2E-02	1.6E-02	8.5E-03	1.1E-02	1.6E-02	3.6E-02	4.8E-02	1.8E-02	1.5E-02	1.3E-02
Isopropyl mercaptan	1	1.4E-01	1.1E-01	7.4E-02	6.0E-02	4.7E-02	7.4E-02	1.8E-01	8.3E-02	1.2E-01	1.1E-01	8.5E-02	4.4E-02	5.7E-02	8.5E-02	1.9E-01	2.5E-01	9.3E-02	7.9E-02	6.6E-02
t-Butyl mercaptan	1	1.3E-01	1.1E-01	7.3E-02	5.9E-02	4.6E-02	7.3E-02	1.7E-01	8.2E-02	1.2E-01	1.1E-01	8.4E-02	4.4E-02	5.6E-02	8.3E-02	1.8E-01	2.5E-01	9.2E-02	7.8E-02	6.5E-02
Ethyl methyl sulfide	11	1.28E-02	1.04E-02	6.98E-03	5.67E-03	4.44E-03	6.94E-03	1.65E-02	7.83E-03	1.10E-02	1.06E-02	8.02E-03	4.17E-03	5.32E-03	7.96E-03	1.74E-02	2.36E-02	8.75E-03	7.44E-03	6.23E-03
Dimethyl disulfide	11	1.6E-02	1.3E-02	8.6E-03	7.0E-03	5.5E-03	8.6E-03	2.0E-02	9.7E-03	1.4E-02	1.3E-02	9.9E-03	5.2E-03	6.6E-03	9.8E-03	2.2E-02	2.9E-02	1.1E-02	9.2E-03	7.7E-03
Carbon disulfide	700	3.3E-09	2.7E-09	1.8E-09	1.5E-09	1.1E-09	1.8E-09	4.3E-09	2.0E-09	2.8E-09	2.7E-09	2.1E-09	1.1E-09	1.4E-09	2.0E-09	4.5E-09	6.1E-09	2.2E-09	1.9E-09	1.6E-09
Sulfur dioxide	365	1.3E-01	1.1E-01	7.1E-02	5.8E-02	4.5E-02	7.1E-02	1.7E-01	8.0E-02	1.1E-01	1.1E-01	8.1E-02	4.2E-02	5.4E-02	8.1E-02	1.8E-01	2.4E-01	8.9E-02	7.6E-02	6.3E-02
Number of Individual HI > 1.0:		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Total HI:	9.2E-01	7.4E-01	5.0E-01	4.1E-01	3.2E-01	5.0E-01	1.2E+00	5.6E-01	7.9E-01	7.6E-01	5.7E-01	3.0E-01	3.8E-01	5.7E-01	1.2E+00	1.7E+00	6.3E-01	5.3E-01	4.5E-01

Locations with Total HI > 1.0:

Country Manor Rehab. and Nursing Ctr.

3 Charmanski Drive (Monitor)

Day Care Center

Case 1B - Current Location - 23 cfm - with supplemental propane - 24-hour averaging period																				
Chemicals	**Acute Tox Values**	**Anna Jacques Hospital**	**Newburyport High School**	**Davenport School**	**Currier School**	**Belleville School**	**Bresnahan School**	**Country Manor Rehab. and Nursing Ctr.**	**Elderly Housing off Low Street**	**Knox Middle School**	**Acute Care/Rehab Facility**	**Hale St. @ Squires Glen Drive**	**3 Doe Run Drive**	**Doe Run Dr. @ turnaround**	**Wildwood @ Quail Run Hollow**	**3 Charmanski Drive (Monitor)**	**Day Care Center**	**Low Street @ Murphy Street**	**K-Mart @ Low Street**	**Merrimac Place Assisted Living**
Hydrogen sulfide	20	1.5E-01	1.2E-01	6.6E-02	6.5E-02	4.2E-02	6.6E-02	1.7E-01	7.2E-02	1.0E-01	1.0E-01	8.4E-02	5.3E-02	3.4E-02	9.2E-02	2.2E-01	2.1E-01	6.6E-02	5.9E-02	8.1E-02
Carbonyl sulfide	20	2.2E-02	1.8E-02	1.0E-02	9.7E-03	6.4E-03	9.9E-03	2.5E-02	1.1E-02	1.5E-02	1.6E-02	1.3E-02	8.0E-03	5.1E-03	1.4E-02	3.3E-02	3.2E-02	9.9E-03	8.9E-03	1.2E-02
Methyl mercaptan	1	5.5E-02	4.4E-02	2.5E-02	2.4E-02	1.6E-02	2.4E-02	6.2E-02	2.7E-02	3.8E-02	3.8E-02	3.1E-02	2.0E-02	1.3E-02	3.4E-02	8.1E-02	7.9E-02	2.4E-02	2.2E-02	3.0E-02
Ethyl mercaptan	1	9.7E-02	7.8E-02	4.4E-02	4.2E-02	2.8E-02	4.3E-02	1.1E-01	4.8E-02	6.8E-02	6.8E-02	5.5E-02	3.5E-02	2.2E-02	6.1E-02	1.4E-01	1.4E-01	4.3E-02	3.9E-02	5.3E-02
Dimethyl sufide	11	1.8E-02	1.5E-02	8.2E-03	8.0E-03	5.2E-03	8.1E-03	2.1E-02	8.9E-03	1.3E-02	1.3E-02	1.0E-02	6.5E-03	4.2E-03	1.1E-02	2.7E-02	2.6E-02	8.1E-03	7.3E-03	1.0E-02
Isopropyl mercaptan	1	9.5E-02	7.6E-02	4.3E-02	4.2E-02	2.7E-02	4.2E-02	1.1E-01	4.6E-02	6.6E-02	6.6E-02	5.4E-02	3.4E-02	2.2E-02	5.9E-02	1.4E-01	1.4E-01	4.2E-02	3.8E-02	5.2E-02
t-Butyl mercaptan	1	9.3E-02	7.5E-02	4.2E-02	4.1E-02	2.7E-02	4.2E-02	1.1E-01	4.6E-02	6.5E-02	6.5E-02	5.3E-02	3.3E-02	2.1E-02	5.8E-02	1.4E-01	1.3E-01	4.2E-02	3.7E-02	5.1E-02
Ethyl methyl sulfide	11	8.92E-03	7.13E-03	4.02E-03	3.90E-03	2.57E-03	3.97E-03	1.02E-02	4.37E-03	6.20E-03	6.25E-03	5.10E-03	3.19E-03	2.04E-03	5.59E-03	1.32E-02	1.28E-02	3.98E-03	3.57E-03	4.91E-03
Dimethyl disulfide	11	1.1E-02	8.8E-03	5.0E-03	4.8E-03	3.2E-03	4.9E-03	1.3E-02	5.4E-03	7.7E-03	7.7E-03	6.3E-03	4.0E-03	2.5E-03	6.9E-03	1.6E-02	1.6E-02	4.9E-03	4.4E-03	6.1E-03
Carbon disulfide	700	2.3E-09	1.8E-09	1.0E-09	1.0E-09	6.6E-10	1.0E-09	2.6E-09	1.1E-09	1.6E-09	1.6E-09	1.3E-09	8.2E-10	5.2E-10	1.4E-09	3.4E-09	3.3E-09	1.0E-09	9.2E-10	1.3E-09
Sulfur dioxide	365	9.1E-02	7.2E-02	4.1E-02	4.0E-02	2.6E-02	4.0E-02	1.0E-01	4.4E-02	6.3E-02	6.3E-02	5.2E-02	3.2E-02	2.1E-02	5.7E-02	1.3E-01	1.3E-01	4.0E-02	3.6E-02	5.0E-02
Number of Individual HI > 1.0:		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Total HI:	6.4E-01	5.1E-01	2.9E-01	2.8E-01	1.8E-01	2.8E-01	7.3E-01	3.1E-01	4.4E-01	4.5E-01	3.6E-01	2.3E-01	1.5E-01	4.0E-01	9.5E-01	9.1E-01	2.8E-01	2.6E-01	3.5E-01

Locations with Total HI > 1.0:

Case 2A - Current Location - 130 cfm - 24-hour averaging period																				
Chemicals	**Acute Tox Values**	**Anna Jacques Hospital**	**Newburyport High School**	**Davenport School**	**Currier School**	**Belleville School**	**Bresnahan School**	**Country Manor Rehab. and Nursing Ctr.**	**Elderly Housing off Low Street**	**Knox Middle School**	**Acute Care/Rehab Facility**	**Hale St. @ Squires Glen Drive**	**3 Doe Run Drive**	**Doe Run Dr. @ turnaround**	**Wildwood @ Quail Run Hollow**	**3 Charmanski Drive (Monitor)**	**Day Care Center**	**Low Street @ Murphy Street**	**K-Mart @ Low Street**	**Merrimac Place Assisted Living**
Hydrogen sulfide	20	7.5E-01	5.9E-01	3.2E-01	3.4E-01	2.2E-01	3.2E-01	8.5E-01	3.5E-01	4.9E-01	5.1E-01	4.3E-01	2.6E-01	1.9E-01	4.8E-01	1.1E+00	1.0E+00	3.6E-01	3.0E-01	4.3E-01
Carbonyl sulfide	20	1.1E-01	8.9E-02	4.9E-02	5.1E-02	3.3E-02	4.8E-02	1.3E-01	5.2E-02	7.4E-02	7.7E-02	6.5E-02	3.9E-02	2.8E-02	7.3E-02	1.7E-01	1.6E-01	5.4E-02	4.5E-02	6.5E-02
Methyl mercaptan	1	2.8E-01	2.2E-01	1.2E-01	1.3E-01	8.2E-02	1.2E-01	3.2E-01	1.3E-01	1.8E-01	1.9E-01	1.6E-01	9.7E-02	6.9E-02	1.8E-01	4.2E-01	3.9E-01	1.3E-01	1.1E-01	1.6E-01
Ethyl mercaptan	1	4.9E-01	3.9E-01	2.1E-01	2.2E-01	1.5E-01	2.1E-01	5.6E-01	2.3E-01	3.2E-01	3.3E-01	2.8E-01	1.7E-01	1.2E-01	3.2E-01	7.5E-01	6.9E-01	2.4E-01	1.9E-01	2.8E-01
Dimethyl sufide	11	9.2E-02	7.3E-02	4.0E-02	4.2E-02	2.7E-02	4.0E-02	1.1E-01	4.3E-02	6.1E-02	6.3E-02	5.3E-02	3.2E-02	2.3E-02	6.0E-02	1.4E-01	1.3E-01	4.4E-02	3.6E-02	5.3E-02
Isopropyl mercaptan	1	4.8E-01	3.8E-01	2.1E-01	2.2E-01	1.4E-01	2.1E-01	5.5E-01	2.2E-01	3.2E-01	3.3E-01	2.8E-01	1.7E-01	1.2E-01	3.1E-01	7.3E-01	6.7E-01	2.3E-01	1.9E-01	2.8E-01
t-Butyl mercaptan	1	4.7E-01	3.7E-01	2.0E-01	2.1E-01	1.4E-01	2.0E-01	5.4E-01	2.2E-01	3.1E-01	3.2E-01	2.7E-01	1.6E-01	1.2E-01	3.1E-01	7.2E-01	6.6E-01	2.3E-01	1.9E-01	2.7E-01
Ethyl methyl sulfide	11	4.52E-02	3.58E-02	1.95E-02	2.04E-02	1.33E-02	1.94E-02	5.17E-02	2.09E-02	2.98E-02	3.07E-02	2.59E-02	1.57E-02	1.12E-02	2.92E-02	6.89E-02	6.31E-02	2.18E-02	1.79E-02	2.59E-02
Dimethyl disulfide	11	5.6E-02	4.4E-02	2.4E-02	2.5E-02	1.6E-02	2.4E-02	6.4E-02	2.6E-02	3.7E-02	3.8E-02	3.2E-02	1.9E-02	1.4E-02	3.6E-02	8.5E-02	7.8E-02	2.7E-02	2.2E-02	3.2E-02
Carbon disulfide	700	1.2E-08	9.2E-09	5.0E-09	5.2E-09	3.4E-09	5.0E-09	1.3E-08	5.4E-09	7.6E-09	7.9E-09	6.7E-09	4.0E-09	2.9E-09	7.5E-09	1.8E-08	1.6E-08	5.6E-09	4.6E-09	6.7E-09
Sulfur dioxide	365	4.6E-01	3.6E-01	2.0E-01	2.1E-01	1.4E-01	2.0E-01	5.3E-01	2.1E-01	3.0E-01	3.1E-01	2.6E-01	1.6E-01	1.1E-01	3.0E-01	7.0E-01	6.4E-01	2.2E-01	1.8E-01	2.6E-01
Number of Individual HI > 1.0:		0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0
	Total HI:	3.2E+00	2.6E+00	1.4E+00	1.5E+00	9.5E-01	1.4E+00	3.7E+00	1.5E+00	2.1E+00	2.2E+00	1.9E+00	1.1E+00	8.1E-01	2.1E+00	4.9E+00	4.5E+00	1.6E+00	1.3E+00	1.9E+00

Locations with Total HI > 1.0:

Anna Jacques Hospital
Newburyport High School
Davenport School
Currier School

Bresnahan School
Country Manor Rehab. and Nursing Ctr.
Elderly Housing off Low Street
Knox Middle School
Acute Care/Rehab Facility
Hale St. @ Squires Glen Drive
3 Doe Run Drive

Wildwood @ Quail Run Hollow
3 Charmanski Drive (Monitor)
Day Care Center
Low Street @ Murphy Street
K-Mart @ Low Street
Merrimac Place Assisted Living

Case 2A - Top of Hill - 130 cfm - 24-hour averaging period																				
Chemicals	**Acute Tox Values**	**Anna Jacques Hospital**	**Newburyport High School**	**Davenport School**	**Currier School**	**Belleville School**	**Bresnahan School**	**Country Manor Rehab. and Nursing Ctr.**	**Elderly Housing off Low Street**	**Knox Middle School**	**Acute Care/Rehab Facility**	**Hale St. @ Squires Glen Drive**	**3 Doe Run Drive**	**Doe Run Dr. @ turnaround**	**Wildwood @ Quail Run Hollow**	**3 Charmanski Drive (Monitor)**	**Day Care Center**	**Low Street @ Murphy Street**	**K-Mart @ Low Street**	**Merrimac Place Assisted Living**
Hydrogen sulfide	20	2.5E-01	2.1E-01	1.1E-01	1.5E-01	1.7E-01	1.6E-01	2.6E-01	1.4E-01	2.2E-01	1.9E-01	3.2E-01	2.4E-01	2.2E-01	3.7E-01	4.8E-01	3.6E-01	3.0E-01	2.8E-01	3.5E-01
Carbonyl sulfide	20	3.7E-02	3.2E-02	1.6E-02	2.3E-02	2.5E-02	2.4E-02	3.9E-02	2.1E-02	3.3E-02	2.8E-02	4.8E-02	3.6E-02	3.2E-02	5.6E-02	7.3E-02	5.4E-02	4.5E-02	4.1E-02	5.2E-02
Methyl mercaptan	1	9.2E-02	7.8E-02	4.1E-02	5.6E-02	6.1E-02	5.9E-02	9.7E-02	5.2E-02	8.2E-02	7.0E-02	1.2E-01	8.9E-02	8.0E-02	1.4E-01	1.8E-01	1.3E-01	1.1E-01	1.0E-01	1.3E-01
Ethyl mercaptan	1	1.6E-01	1.4E-01	7.2E-02	1.0E-01	1.1E-01	1.0E-01	1.7E-01	9.1E-02	1.5E-01	1.2E-01	2.1E-01	1.6E-01	1.4E-01	2.5E-01	3.2E-01	2.4E-01	2.0E-01	1.8E-01	2.3E-01
Dimethyl sufide	11	3.1E-02	2.6E-02	1.3E-02	1.9E-02	2.0E-02	1.9E-02	3.2E-02	1.7E-02	2.7E-02	2.3E-02	3.9E-02	3.0E-02	2.7E-02	4.6E-02	6.0E-02	4.4E-02	3.7E-02	3.4E-02	4.3E-02
Isopropyl mercaptan	1	1.6E-01	1.4E-01	7.0E-02	9.8E-02	1.1E-01	1.0E-01	1.7E-01	8.9E-02	1.4E-01	1.2E-01	2.0E-01	1.5E-01	1.4E-01	2.4E-01	3.1E-01	2.3E-01	1.9E-01	1.8E-01	2.2E-01
t-Butyl mercaptan	1	1.6E-01	1.3E-01	6.9E-02	9.6E-02	1.0E-01	1.0E-01	1.7E-01	8.8E-02	1.4E-01	1.2E-01	2.0E-01	1.5E-01	1.4E-01	2.4E-01	3.1E-01	2.3E-01	1.9E-01	1.7E-01	2.2E-01
Ethyl methyl sulfide	11	1.50E-02	1.27E-02	6.61E-03	9.17E-03	9.98E-03	9.51E-03	1.58E-02	8.38E-03	1.34E-02	1.14E-02	1.91E-02	1.45E-02	1.30E-02	2.27E-02	2.92E-02	2.17E-02	1.82E-02	1.67E-02	2.10E-02
Dimethyl disulfide	11	1.9E-02	1.6E-02	8.2E-03	1.1E-02	1.2E-02	1.2E-02	2.0E-02	1.0E-02	1.7E-02	1.4E-02	2.4E-02	1.8E-02	1.6E-02	2.8E-02	3.6E-02	2.7E-02	2.3E-02	2.1E-02	2.6E-02
Carbon disulfide	700	3.9E-09	3.3E-09	1.7E-09	2.4E-09	2.6E-09	2.4E-09	4.1E-09	2.2E-09	3.4E-09	2.9E-09	4.9E-09	3.7E-09	3.3E-09	5.8E-09	7.5E-09	5.6E-09	4.7E-09	4.3E-09	5.4E-09
Sulfur dioxide	365	1.5E-01	1.3E-01	6.7E-02	9.3E-02	1.0E-01	9.7E-02	1.6E-01	8.5E-02	1.4E-01	1.2E-01	1.9E-01	1.5E-01	1.3E-01	2.3E-01	3.0E-01	2.2E-01	1.9E-01	1.7E-01	2.1E-01
Number of Individual HI > 1.0:		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Total HI:	1.1E+00	9.1E-01	4.7E-01	6.6E-01	7.1E-01	6.8E-01	1.1E+00	6.0E-01	9.6E-01	8.1E-01	1.4E+00	1.0E+00	9.3E-01	1.6E+00	2.1E+00	1.6E+00	1.3E+00	1.2E+00	1.5E+00

Locations with Total HI > 1.0:

Anna Jacques Hospital

Country Manor Rehab. and Nursing Ctr.

Hale St. @ Squires Glen Drive

3 Doe Run Drive

Wildwood @ Quail Run Hollow

3 Charmanski Drive (Monitor)

Day Care Center

Low Street @ Murphy Street

K-Mart @ Low Street

Merrimac Place Assisted Living

Case 2B - Current Location - 130 cfm - with supplemental propane - 24-hour averaging period																				
Chemicals	**Acute Tox Values**	**Anna Jacques Hospital**	**Newburyport High School**	**Davenport School**	**Currier School**	**Belleville School**	**Bresnahan School**	**Country Manor Rehab. and Nursing Ctr.**	**Elderly Housing off Low Street**	**Knox Middle School**	**Acute Care/Rehab Facility**	**Hale St. @ Squires Glen Drive**	**3 Doe Run Drive**	**Doe Run Dr. @ turnaround**	**Wildwood @ Quail Run Hollow**	**3 Charmanski Drive (Monitor)**	**Day Care Center**	**Low Street @ Murphy Street**	**K-Mart @ Low Street**	**Merrimac Place Assisted Living**
Hydrogen sulfide	20	6.5E-01	5.0E-01	2.7E-01	3.0E-01	1.9E-01	2.7E-01	7.3E-01	2.9E-01	4.0E-01	4.2E-01	3.8E-01	2.0E-01	1.7E-01	4.5E-01	1.0E+00	9.1E-01	3.3E-01	2.4E-01	3.9E-01
Carbonyl sulfide	20	9.7E-02	7.6E-02	4.0E-02	4.6E-02	2.9E-02	4.0E-02	1.1E-01	4.3E-02	6.0E-02	6.4E-02	5.7E-02	3.0E-02	2.6E-02	6.8E-02	1.5E-01	1.4E-01	5.0E-02	3.6E-02	5.9E-02
Methyl mercaptan	1	2.4E-01	1.9E-01	9.9E-02	1.1E-01	7.2E-02	1.0E-01	2.7E-01	1.1E-01	1.5E-01	1.6E-01	1.4E-01	7.3E-02	6.5E-02	1.7E-01	3.8E-01	3.4E-01	1.2E-01	9.0E-02	1.5E-01
Ethyl mercaptan	1	4.3E-01	3.3E-01	1.8E-01	2.0E-01	1.3E-01	1.8E-01	4.8E-01	1.9E-01	2.6E-01	2.8E-01	2.5E-01	1.3E-01	1.1E-01	3.0E-01	6.7E-01	6.0E-01	2.2E-01	1.6E-01	2.6E-01
Dimethyl sufide	11	8.0E-02	6.2E-02	3.3E-02	3.7E-02	2.4E-02	3.3E-02	9.0E-02	3.5E-02	4.9E-02	5.2E-02	4.6E-02	2.4E-02	2.2E-02	5.6E-02	1.3E-01	1.1E-01	4.1E-02	3.0E-02	4.8E-02
Isopropyl mercaptan	1	4.2E-01	3.2E-01	1.7E-01	2.0E-01	1.3E-01	1.7E-01	4.7E-01	1.8E-01	2.6E-01	2.7E-01	2.4E-01	1.3E-01	1.1E-01	2.9E-01	6.5E-01	5.8E-01	2.1E-01	1.6E-01	2.5E-01
t-Butyl mercaptan	1	4.1E-01	3.2E-01	1.7E-01	1.9E-01	1.2E-01	1.7E-01	4.6E-01	1.8E-01	2.5E-01	2.7E-01	2.4E-01	1.2E-01	1.1E-01	2.9E-01	6.4E-01	5.8E-01	2.1E-01	1.5E-01	2.5E-01
Ethyl methyl sulfide	11	3.91E-02	3.05E-02	1.62E-02	1.83E-02	1.18E-02	1.62E-02	4.40E-02	1.74E-02	2.42E-02	2.56E-02	2.27E-02	1.19E-02	1.06E-02	2.73E-02	6.14E-02	5.50E-02	2.00E-02	1.46E-02	2.37E-02
Dimethyl disulfide	11	4.8E-02	3.8E-02	2.0E-02	2.3E-02	1.5E-02	2.0E-02	5.4E-02	2.1E-02	3.0E-02	3.2E-02	2.8E-02	1.5E-02	1.3E-02	3.4E-02	7.6E-02	6.8E-02	2.5E-02	1.8E-02	2.9E-02
Carbon disulfide	700	1.0E-08	7.8E-09	4.2E-09	4.7E-09	3.0E-09	4.2E-09	1.1E-08	4.5E-09	6.2E-09	6.6E-09	5.8E-09	3.1E-09	2.7E-09	7.0E-09	1.6E-08	1.4E-08	5.1E-09	3.8E-09	6.1E-09
Sulfur dioxide	365	4.0E-01	3.1E-01	1.6E-01	1.9E-01	1.2E-01	1.6E-01	4.5E-01	1.8E-01	2.5E-01	2.6E-01	2.3E-01	1.2E-01	1.1E-01	2.8E-01	6.2E-01	5.6E-01	2.0E-01	1.5E-01	2.4E-01
Number of Individual HI > 1.0:		0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
	Total HI:	2.8E+00	2.2E+00	1.2E+00	1.3E+00	8.4E-01	1.2E+00	3.1E+00	1.2E+00	1.7E+00	1.8E+00	1.6E+00	8.5E-01	7.6E-01	2.0E+00	4.4E+00	3.9E+00	1.4E+00	1.0E+00	1.7E+00

Locations with Total HI > 1.0:

Anna Jacques Hospital
Newburyport High School
Davenport School
Currier School

Bresnahan School
Country Manor Rehab. and Nursing Ctr.
Elderly Housing off Low Street
Knox Middle School
Acute Care/Rehab Facility
Hale St. @ Squires Glen Drive

Wildwood @ Quail Run Hollow
3 Charmanski Drive (Monitor)
Day Care Center
Low Street @ Murphy Street
K-Mart @ Low Street
Merrimac Place Assisted Living

Case 2B - Top of Hill - 130 cfm - with supplemental propane – 24-hour averaging period																				
Chemicals	**Acute Tox Values**	**Anna Jacques Hospital**	**Newburyport High School**	**Davenport School**	**Currier School**	**Belleville School**	**Bresnahan School**	**Country Manor Rehab. and Nursing Ctr.**	**Elderly Housing off Low Street**	**Knox Middle School**	**Acute Care/Rehab Facility**	**Hale St. @ Squires Glen Drive**	**3 Doe Run Drive**	**Doe Run Dr. @ turnaround**	**Wildwood @ Quail Run Hollow**	**3 Charmanski Drive (Monitor)**	**Day Care Center**	**Low Street @ Murphy Street**	**K-Mart @ Low Street**	**Merrimac Place Assisted Living**
Hydrogen sulfide	20	2.3E-01	1.9E-01	9.8E-02	1.4E-01	1.5E-01	1.4E-01	2.4E-01	1.2E-01	1.9E-01	1.7E-01	2.9E-01	2.2E-01	2.0E-01	3.6E-01	4.5E-01	3.1E-01	2.8E-01	2.5E-01	3.3E-01
Carbonyl sulfide	20	3.4E-02	2.8E-02	1.5E-02	2.1E-02	2.3E-02	2.1E-02	3.5E-02	1.8E-02	2.9E-02	2.5E-02	4.3E-02	3.3E-02	3.0E-02	5.4E-02	6.7E-02	4.7E-02	4.2E-02	3.7E-02	5.0E-02
Methyl mercaptan	1	8.4E-02	7.0E-02	3.7E-02	5.2E-02	5.6E-02	5.2E-02	8.8E-02	4.5E-02	7.2E-02	6.2E-02	1.1E-01	8.0E-02	7.4E-02	1.3E-01	1.7E-01	1.2E-01	1.0E-01	9.2E-02	1.2E-01
Ethyl mercaptan	1	1.5E-01	1.2E-01	6.5E-02	9.3E-02	9.9E-02	9.2E-02	1.6E-01	8.0E-02	1.3E-01	1.1E-01	1.9E-01	1.4E-01	1.3E-01	2.4E-01	2.9E-01	2.1E-01	1.9E-01	1.6E-01	2.2E-01
Dimethyl sufide	11	2.8E-02	2.3E-02	1.2E-02	1.7E-02	1.9E-02	1.7E-02	2.9E-02	1.5E-02	2.4E-02	2.1E-02	3.5E-02	2.7E-02	2.4E-02	4.4E-02	5.5E-02	3.9E-02	3.5E-02	3.0E-02	4.1E-02
Isopropyl mercaptan	1	1.5E-01	1.2E-01	6.3E-02	9.1E-02	9.7E-02	9.0E-02	1.5E-01	7.8E-02	1.2E-01	1.1E-01	1.8E-01	1.4E-01	1.3E-01	2.3E-01	2.9E-01	2.0E-01	1.8E-01	1.6E-01	2.1E-01
t-Butyl mercaptan	1	1.4E-01	1.2E-01	6.2E-02	8.9E-02	9.6E-02	8.9E-02	1.5E-01	7.7E-02	1.2E-01	1.1E-01	1.8E-01	1.4E-01	1.3E-01	2.3E-01	2.8E-01	2.0E-01	1.8E-01	1.6E-01	2.1E-01
Ethyl methyl sulfide	11	1.37E-02	1.14E-02	5.94E-03	8.51E-03	9.13E-03	8.46E-03	1.42E-02	7.34E-03	1.16E-02	1.01E-02	1.74E-02	1.31E-02	1.20E-02	2.17E-02	2.69E-02	1.90E-02	1.70E-02	1.49E-02	2.01E-02
Dimethyl disulfide	11	1.7E-02	1.4E-02	7.3E-03	1.1E-02	1.1E-02	1.0E-02	1.8E-02	9.1E-03	1.4E-02	1.3E-02	2.1E-02	1.6E-02	1.5E-02	2.7E-02	3.3E-02	2.3E-02	2.1E-02	1.8E-02	2.5E-02
Carbon disulfide	700	3.5E-09	2.9E-09	1.5E-09	2.2E-09	2.3E-09	2.2E-09	3.7E-09	1.9E-09	3.0E-09	2.6E-09	4.5E-09	3.4E-09	3.1E-09	5.6E-09	6.9E-09	4.9E-09	4.4E-09	3.8E-09	5.2E-09
Sulfur dioxide	365	1.4E-01	1.2E-01	6.0E-02	8.6E-02	9.3E-02	8.6E-02	1.4E-01	7.5E-02	1.2E-01	1.0E-01	1.8E-01	1.3E-01	1.2E-01	2.2E-01	2.7E-01	1.9E-01	1.7E-01	1.5E-01	2.0E-01
Number of Individual HI > 1.0:		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Total HI:	9.8E-01	8.1E-01	4.3E-01	6.1E-01	6.5E-01	6.1E-01	1.0E+00	5.3E-01	8.3E-01	7.3E-01	1.2E+00	9.4E-01	8.6E-01	1.6E+00	1.9E+00	1.4E+00	1.2E+00	1.1E+00	1.4E+00

Locations with Total HI > 1.0:

Country Manor Rehab. and Nursing Ctr.

Hale St. @ Squires Glen Drive

Wildwood @ Quail Run Hollow
3 Charmanski Drive (Monitor)
Day Care Center
Low Street @ Murphy Street
K-Mart @ Low Street
Merrimac Place Assisted Living

Case 1 A - Current Location - 23 cfm - annual averaging period																			
Chemicals	**Subchronic Tox Values**	**Anna Jacques Hospital**	**Newburyport High School**	**Davenport School**	**Currier School**	**Belleville School**	**Bresnahan School**	**Country Manor Rehab. and Nursing Ctr.**	**Elderly Housing off Low Street**	**Knox Middle School**	**Acute Care/Rehab Facility**	**Hale St. @ Squires Glen Drive**	**3 Doe Run Drive**	**Doe Run Dr. @ turnaround**	**Wildwood @ Quail Run Hollow**	**3 Charmanski Drive (Monitor)**	**Day Care Center**	**Low Street @ Murphy Street**	**K-Mart @ Low Street**	**Merrimac Place Assisted Living**
Hydrogen sulfide	20	1.6E-02	1.1E-02	7.4E-03	7.8E-03	7.2E-03	7.2E-03	3.2E-02	6.0E-03	1.1E-02	1.6E-02	9.9E-03	6.1E-03	5.5E-03	1.6E-02	3.2E-02	2.9E-02	1.5E-02	8.9E-03	8.0E-03
Carbonyl sulfide	20	2.4E-03	1.6E-03	1.1E-03	1.2E-03	1.1E-03	1.1E-03	4.9E-03	9.0E-04	1.6E-03	2.4E-03	1.5E-03	9.2E-04	8.3E-04	2.4E-03	4.9E-03	4.3E-03	2.3E-03	1.3E-03	1.2E-03
Methyl mercaptan	1	5.8E-03	3.9E-03	2.8E-03	2.9E-03	2.7E-03	2.7E-03	1.2E-02	2.2E-03	4.0E-03	5.9E-03	3.7E-03	2.3E-03	2.1E-03	5.8E-03	1.2E-02	1.1E-02	5.7E-03	3.3E-03	3.0E-03
Ethyl mercaptan	1	1.0E-02	6.9E-03	4.9E-03	5.1E-03	4.7E-03	4.8E-03	2.1E-02	3.9E-03	7.2E-03	1.0E-02	6.5E-03	4.0E-03	3.6E-03	1.0E-02	2.1E-02	1.9E-02	1.0E-02	5.9E-03	5.3E-03
Dimethyl sufide	11	1.9E-03	1.3E-03	9.2E-04	9.6E-04	8.9E-04	8.9E-04	4.0E-03	7.4E-04	1.3E-03	2.0E-03	1.2E-03	7.6E-04	6.8E-04	1.9E-03	4.0E-03	3.6E-03	1.9E-03	1.1E-03	9.9E-04
Isopropyl mercaptan	1	1.0E-02	6.8E-03	4.8E-03	5.0E-03	4.6E-03	4.6E-03	2.1E-02	3.8E-03	7.0E-03	1.0E-02	6.4E-03	3.9E-03	3.6E-03	1.0E-02	2.1E-02	1.9E-02	9.9E-03	5.7E-03	5.2E-03
t-Butyl mercaptan	1	9.9E-03	6.7E-03	4.7E-03	4.9E-03	4.6E-03	4.6E-03	2.0E-02	3.8E-03	6.9E-03	1.0E-02	6.3E-03	3.9E-03	3.5E-03	9.9E-03	2.1E-02	1.8E-02	9.7E-03	5.6E-03	5.1E-03
Ethyl methyl sulfide	11	9.5E-04	6.4E-04	4.5E-04	4.7E-04	4.3E-04	4.4E-04	2.0E-03	3.6E-04	6.6E-04	9.6E-04	6.0E-04	3.7E-04	3.3E-04	9.5E-04	2.0E-03	1.7E-03	9.3E-04	5.4E-04	4.9E-04
Dimethyl disulfide	11	1.2E-03	7.9E-04	5.6E-04	5.8E-04	5.4E-04	5.4E-04	2.4E-03	4.5E-04	8.1E-04	1.2E-03	7.4E-04	4.6E-04	4.1E-04	1.2E-03	2.4E-03	2.2E-03	1.1E-03	6.7E-04	6.0E-04
Carbon disulfide	700	2.4E-10	1.6E-10	1.2E-10	1.2E-10	1.1E-10	1.1E-10	5.0E-10	9.3E-11	1.7E-10	2.5E-10	1.5E-10	9.5E-11	8.6E-11	2.4E-10	5.0E-10	4.5E-10	2.4E-10	1.4E-10	1.2E-10
Sulfur dioxide	80	4.4E-02	3.0E-02	2.1E-02	2.2E-02	2.0E-02	2.0E-02	9.0E-02	1.7E-02	3.0E-02	4.5E-02	2.8E-02	1.7E-02	1.5E-02	4.4E-02	9.1E-02	8.1E-02	4.3E-02	2.5E-02	2.2E-02
Number of Individual HI > 1.0:		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Total HI:	1.0E-01	6.9E-02	4.9E-02	5.1E-02	4.7E-02	4.7E-02	2.1E-01	3.9E-02	7.1E-02	1.0E-01	6.4E-02	4.0E-02	3.6E-02	1.0E-01	2.1E-01	1.9E-01	1.0E-01	5.8E-02	5.2E-02

Locations with Total HI > 1.0:

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Case 1B - Current Location - 23 cfm - with supplemental propane - annual averaging period																			
Chemicals	**Subchronic Tox Values**	**Anna Jacques Hospital**	**Newburyport High School**	**Davenport School**	**Currier School**	**Belleville School**	**Bresnahan School**	**Country Manor Rehab. and Nursing Ctr.**	**Elderly Housing off Low Street**	**Knox Middle School**	**Acute Care/Rehab Facility**	**Hale St. @ Squires Glen Drive**	**3 Doe Run Drive**	**Doe Run Dr. @ turnaround**	**Wildwood @ Quail Run Hollow**	**3 Charmanski Drive (Monitor)**	**Day Care Center**	**Low Street @ Murphy Street**	**K-Mart @ Low Street**	**Merrimac Place Assisted Living**
Hydrogen sulfide	20	1.2E-02	7.8E-03	5.2E-03	5.5E-03	4.8E-03	5.4E-03	2.4E-02	4.2E-03	7.8E-03	1.1E-02	7.5E-03	3.7E-03	3.1E-03	1.1E-02	2.6E-02	2.2E-02	9.6E-03	6.3E-03	6.2E-03
Carbonyl sulfide	20	1.8E-03	1.2E-03	7.8E-04	8.3E-04	7.3E-04	8.1E-04	3.7E-03	6.4E-04	1.2E-03	1.7E-03	1.1E-03	5.5E-04	4.7E-04	1.7E-03	3.9E-03	3.3E-03	1.4E-03	9.5E-04	9.4E-04
Methyl mercaptan	1	4.6E-03	2.9E-03	1.9E-03	2.1E-03	1.8E-03	2.0E-03	9.0E-03	1.6E-03	2.9E-03	4.3E-03	2.8E-03	1.4E-03	1.2E-03	4.2E-03	9.6E-03	8.2E-03	3.6E-03	2.3E-03	2.3E-03
Ethyl mercaptan	1	8.1E-03	5.1E-03	3.4E-03	3.6E-03	3.2E-03	3.5E-03	1.6E-02	2.8E-03	5.2E-03	7.5E-03	4.9E-03	2.4E-03	2.0E-03	7.4E-03	1.7E-02	1.4E-02	6.3E-03	4.2E-03	4.1E-03
Dimethyl sufide	11	1.5E-03	9.6E-04	6.4E-04	6.8E-04	6.0E-04	6.6E-04	3.0E-03	5.2E-04	9.7E-04	1.4E-03	9.2E-04	4.5E-04	3.8E-04	1.4E-03	3.2E-03	2.7E-03	1.2E-03	7.8E-04	7.7E-04
Isopropyl mercaptan	1	7.9E-03	5.0E-03	3.3E-03	3.6E-03	3.1E-03	3.4E-03	1.6E-02	2.7E-03	5.0E-03	7.4E-03	4.8E-03	2.4E-03	2.0E-03	7.2E-03	1.7E-02	1.4E-02	6.2E-03	4.1E-03	4.0E-03
t-Butyl mercaptan	1	7.7E-03	4.9E-03	3.3E-03	3.5E-03	3.1E-03	3.4E-03	1.5E-02	2.7E-03	5.0E-03	7.2E-03	4.7E-03	2.3E-03	2.0E-03	7.1E-03	1.6E-02	1.4E-02	6.1E-03	4.0E-03	4.0E-03
Ethyl methyl sulfide	11	7.4E-04	4.7E-04	3.1E-04	3.3E-04	2.9E-04	3.2E-04	1.5E-03	2.6E-04	4.7E-04	6.9E-04	4.5E-04	2.2E-04	1.9E-04	6.8E-04	1.6E-03	1.3E-03	5.8E-04	3.8E-04	3.8E-04
Dimethyl disulfide	11	9.2E-04	5.8E-04	3.9E-04	4.1E-04	3.6E-04	4.0E-04	1.8E-03	3.2E-04	5.9E-04	8.6E-04	5.6E-04	2.7E-04	2.3E-04	8.4E-04	1.9E-03	1.6E-03	7.2E-04	4.7E-04	4.7E-04
Carbon disulfide	700	1.9E-10	1.2E-10	8.1E-11	8.6E-11	7.5E-11	8.3E-11	3.8E-10	6.6E-11	1.2E-10	1.8E-10	1.2E-10	5.7E-11	4.8E-11	1.7E-10	4.0E-10	3.4E-10	1.5E-10	9.8E-11	9.7E-11
Sulfur dioxide	80	3.4E-02	2.2E-02	1.5E-02	1.5E-02	1.4E-02	1.5E-02	6.8E-02	1.2E-02	2.2E-02	3.2E-02	2.1E-02	1.0E-02	8.7E-03	3.2E-02	7.2E-02	6.1E-02	2.7E-02	1.8E-02	1.8E-02
Number of Individual HI > 1.0:		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Total HI:	8.0E-02	5.1E-02	3.4E-02	3.6E-02	3.2E-02	3.5E-02	1.6E-01	2.8E-02	5.1E-02	7.5E-02	4.9E-02	2.4E-02	2.0E-02	7.3E-02	1.7E-01	1.4E-01	6.3E-02	4.1E-02	4.1E-02

Locations with Total HI > 1.0:

Case 2A - Current Location - 130 cfm - annual averaging period																			
Chemicals	**Subchronic Tox Values**	**Anna Jacques Hospital**	**Newburyport High School**	**Davenport School**	**Currier School**	**Belleville School**	**Bresnahan School**	**Country Manor Rehab. and Nursing Ctr.**	**Elderly Housing off Low Street**	**Knox Middle School**	**Acute Care/Rehab Facility**	**Hale St. @ Squires Glen Drive**	**3 Doe Run Drive**	**Doe Run Dr. @ turnaround**	**Wildwood @ Quail Run Hollow**	**3 Charmanski Drive (Monitor)**	**Day Care Center**	**Low Street @ Murphy Street**	**K-Mart @ Low Street**	**Merrimac Place Assisted Living**
Hydrogen sulfide	20	6.4E-02	4.0E-02	2.7E-02	2.9E-02	2.5E-02	2.8E-02	1.2E-01	2.2E-02	4.0E-02	5.9E-02	3.9E-02	1.9E-02	1.6E-02	5.9E-02	1.3E-01	1.1E-01	4.9E-02	3.3E-02	3.3E-02
Carbonyl sulfide	20	9.6E-03	6.1E-03	4.0E-03	4.3E-03	3.8E-03	4.2E-03	1.9E-02	3.3E-03	6.1E-03	8.8E-03	5.9E-03	2.8E-03	2.4E-03	8.9E-03	2.0E-02	1.7E-02	7.4E-03	4.9E-03	5.0E-03
Methyl mercaptan	1	2.4E-02	1.5E-02	9.9E-03	1.1E-02	9.3E-03	1.0E-02	4.6E-02	8.0E-03	1.5E-02	2.2E-02	1.4E-02	7.0E-03	6.0E-03	2.2E-02	5.0E-02	4.2E-02	1.8E-02	1.2E-02	1.2E-02
Ethyl mercaptan	1	4.2E-02	2.7E-02	1.8E-02	1.9E-02	1.6E-02	1.8E-02	8.2E-02	1.4E-02	2.6E-02	3.9E-02	2.6E-02	1.2E-02	1.1E-02	3.9E-02	8.9E-02	7.5E-02	3.3E-02	2.2E-02	2.2E-02
Dimethyl sufide	11	7.9E-03	5.0E-03	3.3E-03	3.5E-03	3.1E-03	3.4E-03	1.5E-02	2.7E-03	5.0E-03	7.2E-03	4.8E-03	2.3E-03	2.0E-03	7.3E-03	1.7E-02	1.4E-02	6.1E-03	4.0E-03	4.1E-03
Isopropyl mercaptan	1	4.1E-02	2.6E-02	1.7E-02	1.8E-02	1.6E-02	1.8E-02	8.0E-02	1.4E-02	2.6E-02	3.8E-02	2.5E-02	1.2E-02	1.0E-02	3.8E-02	8.7E-02	7.3E-02	3.2E-02	2.1E-02	2.1E-02
t-Butyl mercaptan	1	4.0E-02	2.6E-02	1.7E-02	1.8E-02	1.6E-02	1.8E-02	7.9E-02	1.4E-02	2.5E-02	3.7E-02	2.5E-02	1.2E-02	1.0E-02	3.7E-02	8.5E-02	7.2E-02	3.1E-02	2.1E-02	2.1E-02
Ethyl methyl sulfide	11	3.9E-03	2.4E-03	1.6E-03	1.7E-03	1.5E-03	1.7E-03	7.5E-03	1.3E-03	2.4E-03	3.5E-03	2.4E-03	1.1E-03	9.7E-04	3.6E-03	8.1E-03	6.9E-03	3.0E-03	2.0E-03	2.0E-03
Dimethyl disulfide	11	4.8E-03	3.0E-03	2.0E-03	2.1E-03	1.9E-03	2.1E-03	9.3E-03	1.6E-03	3.0E-03	4.4E-03	2.9E-03	1.4E-03	1.2E-03	4.4E-03	1.0E-02	8.5E-03	3.7E-03	2.5E-03	2.5E-03
Carbon disulfide	700	9.9E-10	6.3E-10	4.1E-10	4.4E-10	3.9E-10	4.3E-10	1.9E-09	3.4E-10	6.2E-10	9.1E-10	6.1E-10	2.9E-10	2.5E-10	9.2E-10	2.1E-09	1.8E-09	7.7E-10	5.1E-10	5.2E-10
Sulfur dioxide	80	1.8E-01	1.1E-01	7.5E-02	8.0E-02	7.0E-02	7.8E-02	3.5E-01	6.1E-02	1.1E-01	1.6E-01	1.1E-01	5.3E-02	4.5E-02	1.7E-01	3.8E-01	3.2E-01	1.4E-01	9.2E-02	9.3E-02
Number of Individual HI > 1.0:		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Total HI:	4.2E-01	2.6E-01	1.7E-01	1.9E-01	1.6E-01	1.8E-01	8.1E-01	1.4E-01	2.6E-01	3.8E-01	2.5E-01	1.2E-01	1.0E-01	3.8E-01	8.8E-01	7.4E-01	3.2E-01	2.1E-01	2.2E-01

Locations with Total HI > 1.0:

Case 2B - Current Location - 130 cfm - with supplemental propane - annual averaging period																				
Chemicals	**Subchronic Tox Values**	**Anna Jacques Hospital**	**Newburyport High School**	**Davenport School**	**Currier School**	**Belleville School**	**Bresnahan School**	**Country Manor Rehab. and Nursing Ctr.**	**Elderly Housing off Low Street**	**Knox Middle School**	**Acute Care/Rehab Facility**	**Hale St. @ Squires Glen Drive**	**3 Doe Run Drive**	**Doe Run Dr. @ turnaround**	**Wildwood @ Quail Run Hollow**	**3 Charmanski Drive (Monitor)**	**Day Care Center**	**Low Street @ Murphy Street**	**K-Mart @ Low Street**	**Merrimac Place Assisted Living**
Hydrogen sulfide	20	5.7E-02	3.6E-02	2.4E-02	2.5E-02	2.2E-02	2.5E-02	1.1E-01	1.9E-02	3.5E-02	5.1E-02	3.5E-02	1.7E-02	1.4E-02	5.3E-02	1.2E-01	1.0E-01	4.3E-02	2.9E-02	3.1E-02
Carbonyl sulfide	20	8.6E-03	5.4E-03	3.5E-03	3.8E-03	3.4E-03	3.7E-03	1.6E-02	2.9E-03	5.3E-03	7.7E-03	5.3E-03	2.5E-03	2.2E-03	8.0E-03	1.8E-02	1.5E-02	6.5E-03	4.4E-03	4.6E-03
Methyl mercaptan	1	2.1E-02	1.3E-02	8.8E-03	9.4E-03	8.4E-03	9.2E-03	4.0E-02	7.1E-03	1.3E-02	1.9E-02	1.3E-02	6.2E-03	5.4E-03	2.0E-02	4.5E-02	3.7E-02	1.6E-02	1.1E-02	1.1E-02
Ethyl mercaptan	1	3.7E-02	2.4E-02	1.6E-02	1.7E-02	1.5E-02	1.6E-02	7.1E-02	1.3E-02	2.3E-02	3.4E-02	2.3E-02	1.1E-02	9.5E-03	3.5E-02	7.9E-02	6.6E-02	2.8E-02	1.9E-02	2.0E-02
Dimethyl sufide	11	7.0E-03	4.4E-03	2.9E-03	3.1E-03	2.8E-03	3.1E-03	1.3E-02	2.3E-03	4.4E-03	6.3E-03	4.3E-03	2.1E-03	1.8E-03	6.5E-03	1.5E-02	1.2E-02	5.3E-03	3.6E-03	3.8E-03
Isopropyl mercaptan	1	3.7E-02	2.3E-02	1.5E-02	1.6E-02	1.4E-02	1.6E-02	7.0E-02	1.2E-02	2.3E-02	3.3E-02	2.2E-02	1.1E-02	9.3E-03	3.4E-02	7.8E-02	6.4E-02	2.8E-02	1.9E-02	2.0E-02
t-Butyl mercaptan	1	3.6E-02	2.3E-02	1.5E-02	1.6E-02	1.4E-02	1.6E-02	6.8E-02	1.2E-02	2.2E-02	3.2E-02	2.2E-02	1.1E-02	9.2E-03	3.3E-02	7.6E-02	6.3E-02	2.7E-02	1.8E-02	1.9E-02
Ethyl methyl sulfide	11	3.4E-03	2.2E-03	1.4E-03	1.5E-03	1.4E-03	1.5E-03	6.5E-03	1.2E-03	2.1E-03	3.1E-03	2.1E-03	1.0E-03	8.7E-04	3.2E-03	7.3E-03	6.1E-03	2.6E-03	1.7E-03	1.9E-03
Dimethyl disulfide	11	4.3E-03	2.7E-03	1.8E-03	1.9E-03	1.7E-03	1.9E-03	8.1E-03	1.4E-03	2.6E-03	3.8E-03	2.6E-03	1.3E-03	1.1E-03	4.0E-03	9.0E-03	7.5E-03	3.2E-03	2.2E-03	2.3E-03
Carbon disulfide	700	8.8E-10	5.6E-10	3.7E-10	3.9E-10	3.5E-10	3.9E-10	1.7E-09	3.0E-10	5.5E-10	8.0E-10	5.4E-10	2.6E-10	2.2E-10	8.2E-10	1.9E-09	1.6E-09	6.7E-10	4.5E-10	4.8E-10
Sulfur dioxide	80	1.6E-01	1.0E-01	6.6E-02	7.1E-02	6.3E-02	7.0E-02	3.0E-01	5.3E-02	9.9E-02	1.4E-01	9.8E-02	4.7E-02	4.1E-02	1.5E-01	3.4E-01	2.8E-01	1.2E-01	8.1E-02	8.6E-02
Number of Individual HI > 1.0:		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Total HI:	3.7E-01	2.3E-01	1.5E-01	1.7E-01	1.5E-01	1.6E-01	7.0E-01	1.2E-01	2.3E-01	3.3E-01	2.3E-01	1.1E-01	9.4E-02	3.4E-01	7.9E-01	6.5E-01	2.8E-01	1.9E-01	2.0E-01

Locations with Total HI > 1.0:

Case 2A - Top of Hill - 130 cfm - annual averaging period																			
Chemicals	**Subchronic Tox Values**	**Anna Jacques Hospital**	**Newburyport High School**	**Davenport School**	**Currier School**	**Belleville School**	**Bresnahan School**	**Country Manor Rehab. and Nursing Ctr.**	**Elderly Housing off Low Street**	**Knox Middle School**	**Acute Care/Rehab Facility**	**Hale St. @ Squires Glen Drive**	**3 Doe Run Drive**	**Doe Run Dr. @ turnaround**	**Wildwood @ Quail Run Hollow**	**3 Charmanski Drive (Monitor)**	**Day Care Center**	**Low Street @ Murphy Street**	**K-Mart @ Low Street**	**Merrimac Place Assisted Living**
Hydrogen sulfide	20	2.8E-02	1.9E-02	1.3E-02	1.5E-02	2.0E-02	1.6E-02	5.3E-02	1.2E-02	1.9E-02	2.7E-02	2.6E-02	2.3E-02	2.1E-02	5.4E-02	7.0E-02	4.7E-02	4.3E-02	2.8E-02	3.3E-02
Carbonyl sulfide	20	4.2E-03	2.8E-03	2.0E-03	2.3E-03	3.0E-03	2.5E-03	7.9E-03	1.7E-03	2.9E-03	4.1E-03	4.0E-03	3.5E-03	3.2E-03	8.2E-03	1.1E-02	7.0E-03	6.5E-03	4.2E-03	5.0E-03
Methyl mercaptan	1	1.0E-02	7.0E-03	5.0E-03	5.7E-03	7.4E-03	6.1E-03	2.0E-02	4.3E-03	7.2E-03	1.0E-02	9.8E-03	8.7E-03	7.9E-03	2.0E-02	2.6E-02	1.7E-02	1.6E-02	1.0E-02	1.2E-02
Ethyl mercaptan	1	1.8E-02	1.2E-02	8.9E-03	1.0E-02	1.3E-02	1.1E-02	3.5E-02	7.6E-03	1.3E-02	1.8E-02	1.7E-02	1.5E-02	1.4E-02	3.6E-02	4.6E-02	3.1E-02	2.8E-02	1.8E-02	2.2E-02
Dimethyl sufide	11	3.4E-03	2.3E-03	1.7E-03	1.9E-03	2.5E-03	2.0E-03	6.5E-03	1.4E-03	2.4E-03	3.3E-03	3.2E-03	2.9E-03	2.6E-03	6.7E-03	8.6E-03	5.8E-03	5.3E-03	3.4E-03	4.1E-03
Isopropyl mercaptan	1	1.8E-02	1.2E-02	8.7E-03	9.9E-03	1.3E-02	1.1E-02	3.4E-02	7.4E-03	1.3E-02	1.7E-02	1.7E-02	1.5E-02	1.4E-02	3.5E-02	4.5E-02	3.0E-02	2.8E-02	1.8E-02	2.1E-02
t-Butyl mercaptan	1	1.8E-02	1.2E-02	8.5E-03	9.7E-03	1.3E-02	1.0E-02	3.3E-02	7.3E-03	1.2E-02	1.7E-02	1.7E-02	1.5E-02	1.3E-02	3.4E-02	4.4E-02	3.0E-02	2.7E-02	1.7E-02	2.1E-02
Ethyl methyl sulfide	11	1.7E-03	1.1E-03	8.2E-04	9.3E-04	1.2E-03	1.0E-03	3.2E-03	7.0E-04	1.2E-03	1.6E-03	1.6E-03	1.4E-03	1.3E-03	3.3E-03	4.2E-03	2.8E-03	2.6E-03	1.7E-03	2.0E-03
Dimethyl disulfide	11	2.1E-03	1.4E-03	1.0E-03	1.1E-03	1.5E-03	1.2E-03	3.9E-03	8.6E-04	1.5E-03	2.0E-03	2.0E-03	1.7E-03	1.6E-03	4.1E-03	5.2E-03	3.5E-03	3.2E-03	2.1E-03	2.5E-03
Carbon disulfide	700	4.3E-10	2.9E-10	2.1E-10	2.4E-10	3.1E-10	2.6E-10	8.2E-10	1.8E-10	3.0E-10	4.2E-10	4.1E-10	3.6E-10	3.3E-10	8.5E-10	1.1E-09	7.3E-10	6.7E-10	4.3E-10	5.1E-10
Sulfur dioxide	80	7.8E-02	5.3E-02	3.8E-02	4.3E-02	5.6E-02	4.6E-02	1.5E-01	3.2E-02	5.4E-02	7.6E-02	7.4E-02	6.5E-02	5.9E-02	1.5E-01	2.0E-01	1.3E-01	1.2E-01	7.7E-02	9.2E-02
Number of Individual HI > 1.0:		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Total HI:	1.8E-01	1.2E-01	8.8E-02	1.0E-01	1.3E-01	1.1E-01	3.4E-01	7.5E-02	1.3E-01	1.8E-01	1.7E-01	1.5E-01	1.4E-01	3.5E-01	4.6E-01	3.0E-01	2.8E-01	1.8E-01	2.1E-01

Locations with Total HI > 1.0:

Case 2B - Top of Hill - 130 cfm - with supplemental propane - annual averaging period																			
Chemicals	**Subchronic Tox Values**	**Anna Jacques Hospital**	**Newburyport High School**	**Davenport School**	**Currier School**	**Belleville School**	**Bresnahan School**	**Country Manor Rehab. and Nursing Ctr.**	**Elderly Housing off Low Street**	**Knox Middle School**	**Acute Care/Rehab Facility**	**Hale St. @ Squires Glen Drive**	**3 Doe Run Drive**	**Doe Run Dr. @ turnaround**	**Wildwood @ Quail Run Hollow**	**3 Charmanski Drive (Monitor)**	**Day Care Center**	**Low Street @ Murphy Street**	**K-Mart @ Low Street**	**Merrimac Place Assisted Living**
Hydrogen sulfide	20	2.6E-02	1.8E-02	1.3E-02	1.4E-02	1.8E-02	1.5E-02	4.9E-02	1.1E-02	1.8E-02	2.5E-02	2.4E-02	2.2E-02	2.0E-02	5.1E-02	6.6E-02	4.3E-02	4.0E-02	2.5E-02	3.2E-02
Carbonyl sulfide	20	3.9E-03	2.6E-03	1.9E-03	2.1E-03	2.7E-03	2.3E-03	7.3E-03	1.6E-03	2.7E-03	3.7E-03	3.7E-03	3.3E-03	3.0E-03	7.7E-03	9.9E-03	6.6E-03	6.0E-03	3.8E-03	4.8E-03
Methyl mercaptan	1	9.6E-03	6.5E-03	4.7E-03	5.3E-03	6.7E-03	5.6E-03	1.8E-02	4.0E-03	6.7E-03	9.2E-03	9.1E-03	8.1E-03	7.4E-03	1.9E-02	2.4E-02	1.6E-02	1.5E-02	9.5E-03	1.2E-02
Ethyl mercaptan	1	1.7E-02	1.2E-02	8.3E-03	9.3E-03	1.2E-02	1.0E-02	3.2E-02	7.0E-03	1.2E-02	1.6E-02	1.6E-02	1.4E-02	1.3E-02	3.4E-02	4.3E-02	2.9E-02	2.6E-02	1.7E-02	2.1E-02
Dimethyl sufide	11	3.2E-03	2.2E-03	1.5E-03	1.7E-03	2.2E-03	1.9E-03	6.0E-03	1.3E-03	2.2E-03	3.1E-03	3.0E-03	2.7E-03	2.5E-03	6.3E-03	8.1E-03	5.4E-03	4.9E-03	3.1E-03	3.9E-03
Isopropyl mercaptan	1	1.7E-02	1.1E-02	8.1E-03	9.1E-03	1.2E-02	9.8E-03	3.1E-02	6.9E-03	1.2E-02	1.6E-02	1.6E-02	1.4E-02	1.3E-02	3.3E-02	4.2E-02	2.8E-02	2.6E-02	1.6E-02	2.0E-02
t-Butyl mercaptan	1	1.6E-02	1.1E-02	7.9E-03	9.0E-03	1.1E-02	9.6E-03	3.1E-02	6.8E-03	1.1E-02	1.6E-02	1.5E-02	1.4E-02	1.3E-02	3.2E-02	4.2E-02	2.8E-02	2.5E-02	1.6E-02	2.0E-02
Ethyl methyl sulfide	11	1.6E-03	1.1E-03	7.6E-04	8.6E-04	1.1E-03	9.2E-04	2.9E-03	6.5E-04	1.1E-03	1.5E-03	1.5E-03	1.3E-03	1.2E-03	3.1E-03	4.0E-03	2.6E-03	2.4E-03	1.5E-03	1.9E-03
Dimethyl disulfide	11	1.9E-03	1.3E-03	9.4E-04	1.1E-03	1.4E-03	1.1E-03	3.6E-03	8.0E-04	1.3E-03	1.9E-03	1.8E-03	1.6E-03	1.5E-03	3.8E-03	4.9E-03	3.3E-03	3.0E-03	1.9E-03	2.4E-03
Carbon disulfide	700	4.0E-10	2.7E-10	1.9E-10	2.2E-10	2.8E-10	2.4E-10	7.6E-10	1.7E-10	2.8E-10	3.9E-10	3.8E-10	3.4E-10	3.1E-10	8.0E-10	1.0E-09	6.8E-10	6.2E-10	4.0E-10	4.9E-10
Sulfur dioxide	80	7.2E-02	4.9E-02	3.5E-02	4.0E-02	5.1E-02	4.3E-02	1.4E-01	3.0E-02	5.0E-02	7.0E-02	6.8E-02	6.1E-02	5.6E-02	1.4E-01	1.8E-01	1.2E-01	1.1E-01	7.1E-02	8.8E-02
Number of Individual HI > 1.0:		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Total HI:	1.7E-01	1.1E-01	8.2E-02	9.3E-02	1.2E-01	9.9E-02	3.2E-01	7.0E-02	1.2E-01	1.6E-01	1.6E-01	1.4E-01	1.3E-01	3.3E-01	4.3E-01	2.8E-01	2.6E-01	1.7E-01	2.1E-01

Locations with Total HI > 1.0:

Case 1 A - Current Location - 23 cfm - using 14 µg/m3 for H2S and COS - 1-hour averaging period																			
Chemicals	**Acute Tox Values**	**Anna Jacques Hospital**	**Newburyport High School**	**Davenport School**	**Currier School**	**Belleville School**	**Bresnahan School**	**Country Manor Rehab. and Nursing Ctr.**	**Elderly Housing off Low Street**	**Knox Middle School**	**Acute Care/Rehab Facility**	**Hale St. @ Squires Glen Drive**	**3 Doe Run Drive**	**Doe Run Dr. @ turnaround**	**Wildwood @ Quail Run Hollow**	**3 Charmanski Drive (Monitor)**	**Day Care Center**	**Low Street @ Murphy Street**	**K-Mart @ Low Street**	**Merrimac Place Assisted Living**
Hydrogen sulfide	14	2.4E+00	2.2E+00	1.7E+00	1.8E+00	1.5E+00	1.5E+00	3.7E+00	1.5E+00	2.1E+00	2.5E+00	1.4E+00	1.1E+00	1.1E+00	2.2E+00	3.8E+00	3.7E+00	2.0E+00	1.7E+00	2.1E+00
Carbonyl sulfide	14	3.6E-01	3.3E-01	2.5E-01	2.8E-01	2.2E-01	2.3E-01	5.5E-01	2.2E-01	3.2E-01	3.8E-01	2.1E-01	1.6E-01	1.7E-01	3.4E-01	5.8E-01	5.6E-01	3.0E-01	2.6E-01	3.2E-01
Methyl mercaptan	3	2.1E-01	1.9E-01	1.5E-01	1.6E-01	1.3E-01	1.3E-01	3.2E-01	1.3E-01	1.8E-01	2.2E-01	1.2E-01	9.2E-02	9.9E-02	1.9E-01	3.3E-01	3.2E-01	1.8E-01	1.5E-01	1.8E-01
Ethyl mercaptan	850	1.3E-03	1.2E-03	9.1E-04	1.0E-03	7.9E-04	8.4E-04	2.0E-03	8.0E-04	1.1E-03	1.4E-03	7.7E-04	5.7E-04	6.2E-04	1.2E-03	2.1E-03	2.0E-03	1.1E-03	9.3E-04	1.1E-03
Dimethyl sufide	420	5.4E-03	4.9E-03	3.8E-03	4.2E-03	3.3E-03	3.5E-03	8.3E-03	3.3E-03	4.8E-03	5.6E-03	3.2E-03	2.4E-03	2.6E-03	5.1E-03	8.6E-03	8.4E-03	4.6E-03	3.9E-03	4.8E-03
Isopropyl mercaptan	850	1.3E-03	1.1E-03	8.9E-04	9.7E-04	7.8E-04	8.2E-04	2.0E-03	7.8E-04	1.1E-03	1.3E-03	7.6E-04	5.6E-04	6.1E-04	1.2E-03	2.0E-03	2.0E-03	1.1E-03	9.1E-04	1.1E-03
t-Butyl mercaptan	850	1.3E-03	1.1E-03	8.8E-04	9.6E-04	7.6E-04	8.1E-04	1.9E-03	7.7E-04	1.1E-03	1.3E-03	7.4E-04	5.5E-04	6.0E-04	1.2E-03	2.0E-03	1.9E-03	1.1E-03	8.9E-04	1.1E-03
Ethyl methyl sulfide	420	2.7E-03	2.40E-03	1.87E-03	2.04E-03	1.63E-03	1.71E-03	4.08E-03	1.64E-03	2.33E-03	2.76E-03	1.58E-03	1.17E-03	1.27E-03	2.49E-03	4.23E-03	4.14E-03	2.24E-03	1.90E-03	2.33E-03
Dimethyl disulfide	13	1.1E-01	9.6E-02	7.5E-02	8.1E-02	6.5E-02	6.9E-02	1.6E-01	6.6E-02	9.3E-02	1.1E-01	6.3E-02	4.7E-02	5.1E-02	9.9E-02	1.7E-01	1.7E-01	9.0E-02	7.6E-02	9.3E-02
Carbon disulfide	4100	4.5E-09	4.0E-09	3.1E-09	3.4E-09	2.7E-09	2.9E-09	6.8E-09	2.7E-09	3.9E-09	4.6E-09	2.6E-09	2.0E-09	2.1E-09	4.2E-09	7.1E-09	6.9E-09	3.8E-09	3.2E-09	3.9E-09
Sulfur dioxide	660	5.7E-01	5.1E-01	4.0E-01	4.4E-01	3.5E-01	3.7E-01	8.8E-01	3.5E-01	5.0E-01	5.9E-01	3.4E-01	2.5E-01	2.7E-01	5.3E-01	9.1E-01	8.9E-01	4.8E-01	4.1E-01	5.0E-01
Number of Individual HI > 1.0:		1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	Total HI:	**3.7E+00**	**3.3E+00**	**2.6E+00**	**2.8E+00**	**2.2E+00**	**2.4E+00**	**5.6E+00**	**2.3E+00**	**3.2E+00**	**3.8E+00**	**2.2E+00**	**1.6E+00**	**1.7E+00**	**3.4E+00**	**5.8E+00**	**5.7E+00**	**3.1E+00**	**2.6E+00**	**3.2E+00**

Locations with Total HI > 1.0:

Anna Jacques Hospital
Newburyport High School
Davenport School
Currier School
Belleville School
Bresnahan School
Country Manor Rehab. and Nursing Ctr.
Elderly Housing off Low Street
Knox Middle School
Acute Care/Rehab Facility
Hale St. @ Squires Glen Drive
3 Doe Run Drive
Doe Run Dr. @ turnaround
Wildwood @ Quail Run Hollow
3 Charmanski Drive (Monitor)
Day Care Center
Low Street @ Murphy Street
K-Mart @ Low Street
Merrimac Place Assisted Living

Case 1B - Current Location - 23 cfm - with supplemental propane - using 14 µg/m3 for H2S and COS - 1-hour averaging period																			
Chemicals	**Acute Tox Values**	**Anna Jacques Hospital**	**Newburyport High School**	**Davenport School**	**Currier School**	**Belleville School**	**Bresnahan School**	**Country Manor Rehab. and Nursing Ctr.**	**Elderly Housing off Low Street**	**Knox Middle School**	**Acute Care/Rehab Facility**	**Hale St. @ Squires Glen Drive**	**3 Doe Run Drive**	**Doe Run Dr. @ turnaround**	**Wildwood @ Quail Run Hollow**	**3 Charmanski Drive (Monitor)**	**Day Care Center**	**Low Street @ Murphy Street**	**K-Mart @ Low Street**	**Merrimac Place Assisted Living**
Hydrogen sulfide	14	1.6E+00	1.4E+00	1.0E+00	1.1E+00	8.6E-01	9.6E-01	2.1E+00	9.1E-01	1.3E+00	1.6E+00	9.0E-01	5.2E-01	3.7E-01	1.6E+00	2.2E+00	2.2E+00	6.5E-01	5.8E-01	1.6E+00
Carbonyl sulfide	14	2.4E-01	2.1E-01	1.5E-01	1.7E-01	1.3E-01	1.5E-01	3.1E-01	1.4E-01	2.0E-01	2.4E-01	1.4E-01	7.8E-02	5.6E-02	2.4E-01	3.3E-01	3.4E-01	9.8E-02	8.8E-02	2.4E-01
Methyl mercaptan	3	1.4E-01	1.2E-01	8.7E-02	9.5E-02	7.4E-02	8.4E-02	1.8E-01	7.9E-02	1.2E-01	1.4E-01	7.8E-02	4.5E-02	3.2E-02	1.4E-01	1.9E-01	1.9E-01	5.6E-02	5.1E-02	1.4E-01
Ethyl mercaptan	850	8.7E-04	7.4E-04	5.5E-04	5.9E-04	4.6E-04	5.2E-04	1.1E-03	4.9E-04	7.2E-04	8.6E-04	4.9E-04	2.8E-04	2.0E-04	8.6E-04	1.2E-03	1.2E-03	3.5E-04	3.2E-04	8.6E-04
Dimethyl sufide	420	3.6E-03	3.1E-03	2.3E-03	2.5E-03	1.9E-03	2.2E-03	4.7E-03	2.1E-03	3.0E-03	3.6E-03	2.0E-03	1.2E-03	8.4E-04	3.6E-03	4.9E-03	5.0E-03	1.5E-03	1.3E-03	3.6E-03
Isopropyl mercaptan	850	8.5E-04	7.2E-04	5.3E-04	5.8E-04	4.5E-04	5.1E-04	1.1E-03	4.8E-04	7.1E-04	8.4E-04	4.7E-04	2.7E-04	2.0E-04	8.4E-04	1.2E-03	1.2E-03	3.4E-04	3.1E-04	8.4E-04
t-Butyl mercaptan	850	8.4E-04	7.1E-04	5.2E-04	5.7E-04	4.5E-04	5.0E-04	1.1E-03	4.7E-04	7.0E-04	8.3E-04	4.7E-04	2.7E-04	1.9E-04	8.2E-04	1.1E-03	1.2E-03	3.4E-04	3.0E-04	8.2E-04
Ethyl methyl sulfide	420	1.79E-03	1.52E-03	1.12E-03	1.22E-03	9.50E-04	1.07E-03	2.29E-03	1.01E-03	1.48E-03	1.76E-03	9.94E-04	5.73E-04	4.14E-04	1.75E-03	2.41E-03	2.47E-03	7.21E-04	6.46E-04	1.75E-03
Dimethyl disulfide	13	7.1E-02	6.1E-02	4.5E-02	4.9E-02	3.8E-02	4.3E-02	9.1E-02	4.0E-02	5.9E-02	7.1E-02	4.0E-02	2.3E-02	1.7E-02	7.0E-02	9.6E-02	9.9E-02	2.9E-02	2.6E-02	7.0E-02
Carbon disulfide	4100	3.0E-09	2.5E-09	1.9E-09	2.0E-09	1.6E-09	1.8E-09	3.8E-09	1.7E-09	2.5E-09	3.0E-09	1.7E-09	9.6E-10	6.9E-10	2.9E-09	4.0E-09	4.1E-09	1.2E-09	1.1E-09	2.9E-09
Sulfur dioxide	660	3.8E-01	3.3E-01	2.4E-01	2.6E-01	2.0E-01	2.3E-01	4.9E-01	2.2E-01	3.2E-01	3.8E-01	2.1E-01	1.2E-01	8.9E-02	3.8E-01	5.2E-01	5.3E-01	1.5E-01	1.4E-01	3.8E-01
Number of Individual HI > 1.0:		1	1	1	1	0	0	1	0	1	1	0	0	0	1	1	1	0	0	1
	Total HI:	**2.5E+00**	**2.1E+00**	**1.5E+00**	**1.7E+00**	**1.3E+00**	**1.5E+00**	**3.1E+00**	**1.4E+00**	**2.0E+00**	**2.4E+00**	**1.4E+00**	**7.9E-01**	**5.7E-01**	**2.4E+00**	**3.3E+00**	**3.4E+00**	**9.9E-01**	**8.9E-01**	**2.4E+00**

Locations with Total HI > 1.0:

Anna Jacques Hospital
Newburyport High School
Davenport School
Currier School
Belleville School
Bresnahan School
Country Manor Rehab. and Nursing Ctr.
Elderly Housing off Low Street
Knox Middle School
Acute Care/Rehab Facility
Hale St. @ Squires Glen Drive

Wildwood @ Quail Run Hollow
3 Charmanski Drive (Monitor)
Day Care Center

Merrimac Place Assisted Living

Case 2A - Current Location - 130 cfm - using 14 µg/m3 for H2S and COS - 1-hour averaging period																			
Chemicals	**Acute Tox Values**	**Anna Jacques Hospital**	**Newburyport High School**	**Davenport School**	**Currier School**	**Belleville School**	**Bresnahan School**	**Country Manor Rehab. and Nursing Ctr.**	**Elderly Housing off Low Street**	**Knox Middle School**	**Acute Care/Rehab Facility**	**Hale St. @ Squires Glen Drive**	**3 Doe Run Drive**	**Doe Run Dr. @ turnaround**	**Wildwood @ Quail Run Hollow**	**3 Charmanski Drive (Monitor)**	**Day Care Center**	**Low Street @ Murphy Street**	**K-Mart @ Low Street**	**Merrimac Place Assisted Living**
Hydrogen sulfide	14	8.1E+00	6.8E+00	5.0E+00	5.5E+00	4.2E+00	4.9E+00	1.0E+01	4.4E+00	6.5E+00	7.8E+00	4.4E+00	2.8E+00	1.7E+00	8.1E+00	1.1E+01	1.1E+01	2.7E+00	3.1E+00	8.2E+00
Carbonyl sulfide	14	1.2E+00	1.0E+00	7.6E-01	8.3E-01	6.3E-01	7.4E-01	1.5E+00	6.7E-01	9.8E-01	1.2E+00	6.7E-01	4.2E-01	2.6E-01	1.2E+00	1.6E+00	1.7E+00	4.1E-01	4.7E-01	1.2E+00
Methyl mercaptan	3	7.0E-01	5.9E-01	4.4E-01	4.8E-01	3.6E-01	4.2E-01	8.9E-01	3.9E-01	5.7E-01	6.8E-01	3.8E-01	2.4E-01	1.5E-01	7.0E-01	9.4E-01	9.5E-01	2.4E-01	2.7E-01	7.1E-01
Ethyl mercaptan	850	4.4E-03	3.7E-03	2.7E-03	3.0E-03	2.3E-03	2.7E-03	5.5E-03	2.4E-03	3.5E-03	4.2E-03	2.4E-03	1.5E-03	9.5E-04	4.4E-03	5.9E-03	5.9E-03	1.5E-03	1.7E-03	4.5E-03
Dimethyl sufide	420	1.8E-02	1.5E-02	1.1E-02	1.2E-02	9.5E-03	1.1E-02	2.3E-02	1.0E-02	1.5E-02	1.8E-02	1.0E-02	6.2E-03	3.9E-03	1.8E-02	2.5E-02	2.5E-02	6.2E-03	7.0E-03	1.9E-02
Isopropyl mercaptan	850	4.3E-03	3.6E-03	2.7E-03	2.9E-03	2.2E-03	2.6E-03	5.4E-03	2.4E-03	3.5E-03	4.1E-03	2.3E-03	1.5E-03	9.3E-04	4.3E-03	5.7E-03	5.8E-03	1.4E-03	1.6E-03	4.4E-03
t-Butyl mercaptan	850	4.2E-03	3.5E-03	2.6E-03	2.9E-03	2.2E-03	2.5E-03	5.3E-03	2.3E-03	3.4E-03	4.1E-03	2.3E-03	1.4E-03	9.1E-04	4.2E-03	5.7E-03	5.7E-03	1.4E-03	1.6E-03	4.3E-03
Ethyl methyl sulfide	420	8.95E-03	7.55E-03	5.56E-03	6.12E-03	4.66E-03	5.42E-03	1.13E-02	4.93E-03	7.24E-03	8.65E-03	4.91E-03	3.06E-03	1.94E-03	8.97E-03	1.20E-02	1.22E-02	3.03E-03	3.44E-03	9.13E-03
Dimethyl disulfide	13	3.6E-01	3.0E-01	2.2E-01	2.4E-01	1.9E-01	2.2E-01	4.5E-01	2.0E-01	2.9E-01	3.5E-01	2.0E-01	1.2E-01	7.7E-02	3.6E-01	4.8E-01	4.9E-01	1.2E-01	1.4E-01	3.6E-01
Carbon disulfide	4100	1.5E-08	1.3E-08	9.3E-09	1.0E-08	7.8E-09	9.1E-09	1.9E-08	8.2E-09	1.2E-08	1.4E-08	8.2E-09	5.1E-09	3.2E-09	1.5E-08	2.0E-08	2.0E-08	5.1E-09	5.8E-09	1.5E-08
Sulfur dioxide	660	1.9E+00	1.6E+00	1.2E+00	1.3E+00	1.0E+00	1.2E+00	2.4E+00	1.1E+00	1.6E+00	1.9E+00	1.1E+00	6.6E-01	4.2E-01	1.9E+00	2.6E+00	2.6E+00	6.5E-01	7.4E-01	2.0E+00
Number of Individual HI > 1.0:		3	3	2	2	1	2	3	2	2	3	2	1	1	3	3	3	1	1	3
	Total HI:	**1.2E+01**	**1.0E+01**	**7.7E+00**	**8.4E+00**	**6.4E+00**	**7.5E+00**	**1.6E+01**	**6.8E+00**	**1.0E+01**	**1.2E+01**	**6.8E+00**	**4.2E+00**	**2.7E+00**	**1.2E+01**	**1.7E+01**	**1.7E+01**	**4.2E+00**	**4.7E+00**	**1.3E+01**

Locations with Total HI > 1.0:

Anna Jacques Hospital
Newburyport High School
Davenport School
Currier School
Belleville School
Bresnahan School
Country Manor Rehab. and Nursing Ctr.
Elderly Housing off Low Street
Knox Middle School
Acute Care/Rehab Facility
Hale St. @ Squires Glen Drive
3 Doe Run Drive
Doe Run Dr. @ turnaround
Wildwood @ Quail Run Hollow
3 Charmanski Drive (Monitor)
Day Care Center
Low Street @ Murphy Street
K-Mart @ Low Street
Merrimac Place Assisted Living

Case 2B - Current Location - 130 cfm - with supplemental propane - using 14 µg/m3 for H2S and COS - 1-hour averaging period																			
Chemicals	**Acute Tox Values**	**Anna Jacques Hospital**	**Newburyport High School**	**Davenport School**	**Currier School**	**Belleville School**	**Bresnahan School**	**Country Manor Rehab. and Nursing Ctr.**	**Elderly Housing off Low Street**	**Knox Middle School**	**Acute Care/Rehab Facility**	**Hale St. @ Squires Glen Drive**	**3 Doe Run Drive**	**Doe Run Dr. @ turnaround**	**Wildwood @ Quail Run Hollow**	**3 Charmanski Drive (Monitor)**	**Day Care Center**	**Low Street @ Murphy Street**	**K-Mart @ Low Street**	**Merrimac Place Assisted Living**
Hydrogen sulfide	14	7.0E+00	5.8E+00	4.3E+00	4.8E+00	3.5E+00	4.3E+00	8.6E+00	3.7E+00	5.5E+00	6.5E+00	3.7E+00	2.5E+00	1.2E+00	7.1E+00	9.2E+00	9.4E+00	1.9E+00	2.9E+00	7.4E+00
Carbonyl sulfide	14	1.1E+00	8.7E-01	6.4E-01	7.2E-01	5.3E-01	6.4E-01	1.3E+00	5.6E-01	8.3E-01	9.8E-01	5.6E-01	3.8E-01	1.8E-01	1.1E+00	1.4E+00	1.4E+00	2.9E-01	4.3E-01	1.1E+00
Methyl mercaptan	3	6.1E-01	5.0E-01	3.7E-01	4.1E-01	3.0E-01	3.7E-01	7.5E-01	3.2E-01	4.8E-01	5.6E-01	3.2E-01	2.2E-01	1.0E-01	6.2E-01	8.0E-01	8.1E-01	1.7E-01	2.5E-01	6.4E-01
Ethyl mercaptan	850	3.8E-03	3.1E-03	2.3E-03	2.6E-03	1.9E-03	2.3E-03	4.7E-03	2.0E-03	3.0E-03	3.5E-03	2.0E-03	1.4E-03	6.3E-04	3.9E-03	5.0E-03	5.1E-03	1.0E-03	1.6E-03	4.0E-03
Dimethyl sufide	420	1.6E-02	1.3E-02	9.6E-03	1.1E-02	7.9E-03	9.7E-03	1.9E-02	8.3E-03	1.2E-02	1.5E-02	8.4E-03	5.7E-03	2.6E-03	1.6E-02	2.1E-02	2.1E-02	4.3E-03	6.5E-03	1.7E-02
Isopropyl mercaptan	850	3.7E-03	3.1E-03	2.3E-03	2.5E-03	1.9E-03	2.3E-03	4.6E-03	2.0E-03	2.9E-03	3.4E-03	2.0E-03	1.3E-03	6.2E-04	3.8E-03	4.9E-03	5.0E-03	1.0E-03	1.5E-03	3.9E-03
t-Butyl mercaptan	850	3.7E-03	3.0E-03	2.2E-03	2.5E-03	1.8E-03	2.2E-03	4.5E-03	1.9E-03	2.9E-03	3.4E-03	1.9E-03	1.3E-03	6.1E-04	3.7E-03	4.8E-03	4.9E-03	1.0E-03	1.5E-03	3.9E-03
Ethyl methyl sulfide	420	7.81E-03	6.40E-03	4.72E-03	5.28E-03	3.88E-03	4.74E-03	9.56E-03	4.09E-03	6.09E-03	7.21E-03	4.14E-03	2.82E-03	1.30E-03	7.89E-03	1.02E-02	1.04E-02	2.12E-03	3.18E-03	8.20E-03
Dimethyl disulfide	13	3.1E-01	2.6E-01	1.9E-01	2.1E-01	1.6E-01	1.9E-01	3.8E-01	1.6E-01	2.4E-01	2.9E-01	1.7E-01	1.1E-01	5.2E-02	3.2E-01	4.1E-01	4.2E-01	8.5E-02	1.3E-01	3.3E-01
Carbon disulfide	4100	1.3E-08	1.1E-08	7.9E-09	8.8E-09	6.5E-09	7.9E-09	1.6E-08	6.8E-09	1.0E-08	1.2E-08	6.9E-09	4.7E-09	2.2E-09	1.3E-08	1.7E-08	1.7E-08	3.5E-09	5.3E-09	1.4E-08
Sulfur dioxide	660	1.7E+00	1.4E+00	1.0E+00	1.1E+00	8.3E-01	1.0E+00	2.1E+00	8.8E-01	1.3E+00	1.5E+00	8.9E-01	6.0E-01	2.8E-01	1.7E+00	2.2E+00	2.2E+00	4.5E-01	6.8E-01	1.8E+00
Number of Individual HI > 1.0:		3	2	2	2	1	2	3	1	2	2	1	1	1	3	3	3	1	1	3
	Total HI:	**1.1E+01**	**8.8E+00**	**6.5E+00**	**7.3E+00**	**5.3E+00**	**6.5E+00**	**1.3E+01**	**5.6E+00**	**8.4E+00**	**9.9E+00**	**5.7E+00**	**3.9E+00**	**1.8E+00**	**1.1E+01**	**1.4E+01**	**1.4E+01**	**2.9E+00**	**4.4E+00**	**1.1E+01**

Locations with Total HI > 1.0:

Anna Jacques Hospital
Newburyport High School
Davenport School
Currier School
Belleville School
Bresnahan School
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Elderly Housing off Low Street
Knox Middle School
Acute Care/Rehab Facility
Hale St. @ Squires Glen Drive
3 Doe Run Drive
Doe Run Dr. @ turnaround
Wildwood @ Quail Run Hollow
3 Charmanski Drive (Monitor)
Day Care Center
Low Street @ Murphy Street
K-Mart @ Low Street
Merrimac Place Assisted Living

Case 2A - Top of Hill - 130 cfm - using 14 µg/m3 for H2S and COS - 1-hour averaging period																				
Chemicals	**Acute Tox Values**	**Anna Jacques Hospital**	**Newburyport High School**	**Davenport School**	**Currier School**	**Belleville School**	**Bresnahan School**	**Country Manor Rehab. and Nursing Ctr.**	**Elderly Housing off Low Street**	**Knox Middle School**	**Acute Care/Rehab Facility**	**Hale St. @ Squires Glen Drive**	**3 Doe Run Drive**	**Doe Run Dr. @ turnaround**	**Wildwood @ Quail Run Hollow**	**3 Charmanski Drive (Monitor)**	**Day Care Center**	**Low Street @ Murphy Street**	**K-Mart @ Low Street**	**Merrimac Place Assisted Living**
Hydrogen sulfide	14	3.5E-01	3.0E-01	1.6E-01	2.2E-01	2.4E-01	2.2E-01	3.7E-01	2.0E-01	3.2E-01	2.7E-01	4.5E-01	3.4E-01	3.1E-01	5.4E-01	6.9E-01	5.1E-01	4.3E-01	3.9E-01	5.0E-01
Carbonyl sulfide	14	5.3E-02	4.5E-02	2.4E-02	3.3E-02	3.6E-02	3.4E-02	5.6E-02	3.0E-02	4.8E-02	4.0E-02	6.8E-02	5.2E-02	4.6E-02	8.1E-02	1.0E-01	7.7E-02	6.5E-02	5.9E-02	7.5E-02
Methyl mercaptan	3	3.1E-02	2.6E-02	1.4E-02	1.9E-02	2.0E-02	2.0E-02	3.2E-02	1.7E-02	2.7E-02	2.3E-02	3.9E-02	3.0E-02	2.7E-02	4.6E-02	6.0E-02	4.4E-02	3.7E-02	3.4E-02	4.3E-02
Ethyl mercaptan	850	1.9E-04	1.6E-04	8.5E-05	1.2E-04	1.3E-04	1.2E-04	2.0E-04	1.1E-04	1.7E-04	1.5E-04	2.4E-04	1.9E-04	1.7E-04	2.9E-04	3.7E-04	2.8E-04	2.3E-04	2.1E-04	2.7E-04
Dimethyl sufide	420	8.0E-04	6.8E-04	3.5E-04	4.9E-04	5.3E-04	5.1E-04	8.4E-04	4.5E-04	7.1E-04	6.1E-04	1.0E-03	7.8E-04	7.0E-04	1.2E-03	1.6E-03	1.2E-03	9.7E-04	8.9E-04	1.1E-03
Isopropyl mercaptan	850	1.9E-04	1.6E-04	8.3E-05	1.1E-04	1.2E-04	1.2E-04	2.0E-04	1.0E-04	1.7E-04	1.4E-04	2.4E-04	1.8E-04	1.6E-04	2.8E-04	3.7E-04	2.7E-04	2.3E-04	2.1E-04	2.6E-04
t-Butyl mercaptan	850	1.8E-04	1.6E-04	8.1E-05	1.1E-04	1.2E-04	1.2E-04	1.9E-04	1.0E-04	1.6E-04	1.4E-04	2.4E-04	1.8E-04	1.6E-04	2.8E-04	3.6E-04	2.7E-04	2.2E-04	2.1E-04	2.6E-04
Ethyl methyl sulfide	420	3.93E-04	3.32E-04	1.73E-04	2.40E-04	2.61E-04	2.49E-04	4.14E-04	2.20E-04	3.50E-04	2.98E-04	5.00E-04	3.80E-04	3.41E-04	5.94E-04	7.65E-04	5.67E-04	4.78E-04	4.36E-04	5.49E-04
Dimethyl disulfide	13	1.6E-02	1.3E-02	6.9E-03	9.6E-03	1.0E-02	1.0E-02	1.7E-02	8.8E-03	1.4E-02	1.2E-02	2.0E-02	1.5E-02	1.4E-02	2.4E-02	3.1E-02	2.3E-02	1.9E-02	1.7E-02	2.2E-02
Carbon disulfide	4100	6.6E-10	5.6E-10	2.9E-10	4.0E-10	4.4E-10	4.2E-10	6.9E-10	3.7E-10	5.9E-10	5.0E-10	8.4E-10	6.4E-10	5.7E-10	9.9E-10	1.3E-09	9.5E-10	8.0E-10	7.3E-10	9.2E-10
Sulfur dioxide	660	8.4E-02	7.1E-02	3.7E-02	5.2E-02	5.6E-02	5.3E-02	8.9E-02	4.7E-02	7.5E-02	6.4E-02	1.1E-01	8.2E-02	7.3E-02	1.3E-01	1.6E-01	1.2E-01	1.0E-01	9.4E-02	1.2E-01
Number of Individual HI > 1.0:		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Total HI:	**5.4E-01**	**4.6E-01**	**2.4E-01**	**3.3E-01**	**3.6E-01**	**3.4E-01**	**5.7E-01**	**3.0E-01**	**4.8E-01**	**4.1E-01**	**6.9E-01**	**5.2E-01**	**4.7E-01**	**8.2E-01**	**1.1E+00**	**7.8E-01**	**6.6E-01**	**6.0E-01**	**7.5E-01**

Locations with Total HI > 1.0:
3 Charmanski Drive (Monitor)

Case 2B - Top of Hill - 130 cfm - with supplemental propane - using 14 µg/m3 for H2S and COS - 1-hour averaging period																				
Chemicals	**Acute Tox Values**	**Anna Jacques Hospital**	**Newburyport High School**	**Davenport School**	**Currier School**	**Belleville School**	**Bresnahan School**	**Country Manor Rehab. and Nursing Ctr.**	**Elderly Housing off Low Street**	**Knox Middle School**	**Acute Care/Rehab Facility**	**Hale St. @ Squires Glen Drive**	**3 Doe Run Drive**	**Doe Run Dr. @ turnaround**	**Wildwood @ Quail Run Hollow**	**3 Charmanski Drive (Monitor)**	**Day Care Center**	**Low Street @ Murphy Street**	**K-Mart @ Low Street**	**Merrimac Place Assisted Living**
Hydrogen sulfide	14	3.2E-01	2.7E-01	1.4E-01	2.0E-01	2.2E-01	2.0E-01	3.4E-01	1.7E-01	2.8E-01	2.4E-01	4.1E-01	3.1E-01	2.8E-01	5.1E-01	6.4E-01	4.5E-01	4.0E-01	3.5E-01	4.7E-01
Carbonyl sulfide	14	4.9E-02	4.0E-02	2.1E-02	3.0E-02	3.2E-02	3.0E-02	5.1E-02	2.6E-02	4.1E-02	3.6E-02	6.2E-02	4.6E-02	4.3E-02	7.7E-02	9.6E-02	6.8E-02	6.1E-02	5.3E-02	7.1E-02
Methyl mercaptan	3	2.8E-02	2.3E-02	1.2E-02	1.7E-02	1.9E-02	1.7E-02	2.9E-02	1.5E-02	2.4E-02	2.1E-02	3.6E-02	2.7E-02	2.5E-02	4.4E-02	5.5E-02	3.9E-02	3.5E-02	3.1E-02	4.1E-02
Ethyl mercaptan	850	1.8E-04	1.5E-04	7.6E-05	1.1E-04	1.2E-04	1.1E-04	1.8E-04	9.4E-05	1.5E-04	1.3E-04	2.2E-04	1.7E-04	1.5E-04	2.8E-04	3.5E-04	2.4E-04	2.2E-04	1.9E-04	2.6E-04
Dimethyl sufide	420	7.3E-04	6.1E-04	3.2E-04	4.5E-04	4.9E-04	4.5E-04	7.6E-04	3.9E-04	6.2E-04	5.4E-04	9.3E-04	7.0E-04	6.4E-04	1.2E-03	1.4E-03	1.0E-03	9.1E-04	8.0E-04	1.1E-03
Isopropyl mercaptan	850	1.7E-04	1.4E-04	7.4E-05	1.1E-04	1.1E-04	1.1E-04	1.8E-04	9.2E-05	1.5E-04	1.3E-04	2.2E-04	1.6E-04	1.5E-04	2.7E-04	3.4E-04	2.4E-04	2.1E-04	1.9E-04	2.5E-04
t-Butyl mercaptan	850	1.7E-04	1.4E-04	7.3E-05	1.0E-04	1.1E-04	1.0E-04	1.8E-04	9.0E-05	1.4E-04	1.2E-04	2.1E-04	1.6E-04	1.5E-04	2.7E-04	3.3E-04	2.3E-04	2.1E-04	1.8E-04	2.5E-04
Ethyl methyl sulfide	420	3.59E-04	2.98E-04	1.55E-04	2.23E-04	2.39E-04	2.22E-04	3.73E-04	1.92E-04	3.05E-04	2.65E-04	4.55E-04	3.42E-04	3.13E-04	5.67E-04	7.06E-04	4.98E-04	4.46E-04	3.91E-04	5.25E-04
Dimethyl disulfide	13	1.4E-02	1.2E-02	6.2E-03	8.9E-03	9.6E-03	8.9E-03	1.5E-02	7.7E-03	1.2E-02	1.1E-02	1.8E-02	1.4E-02	1.3E-02	2.3E-02	2.8E-02	2.0E-02	1.8E-02	1.6E-02	2.1E-02
Carbon disulfide	4100	6.0E-10	5.0E-10	2.6E-10	3.7E-10	4.0E-10	3.7E-10	6.2E-10	3.2E-10	5.1E-10	4.4E-10	7.6E-10	5.7E-10	5.2E-10	9.5E-10	1.2E-09	8.3E-10	7.5E-10	6.5E-10	8.8E-10
Sulfur dioxide	660	7.7E-02	6.4E-02	3.3E-02	4.8E-02	5.1E-02	4.8E-02	8.0E-02	4.1E-02	6.5E-02	5.7E-02	9.7E-02	7.3E-02	6.7E-02	1.2E-01	1.5E-01	1.1E-01	9.6E-02	8.4E-02	1.1E-01
Number of Individual HI > 1.0:		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Total HI:	**4.9E-01**	**4.1E-01**	**2.1E-01**	**3.1E-01**	**3.3E-01**	**3.0E-01**	**5.1E-01**	**2.6E-01**	**4.2E-01**	**3.7E-01**	**6.3E-01**	**4.7E-01**	**4.3E-01**	**7.8E-01**	**9.7E-01**	**6.8E-01**	**6.1E-01**	**5.4E-01**	**7.2E-01**

Locations with Total HI > 1.0:

APPENDIX C.

RESULTS OF FREQUENCY ANALYSES

Table C-1 Case 1A Hydrogen Sulfide Exceedances Modeling Low Gas Flow Rate without Propane

Location	Number of hours per year predicted to exceed 42 ug/m^3 H_2S Model Efficiency Assumption		Number of hours per year predicted to exceed 14 ug/m^3 H_2S Model Efficiency Assumption	
	80%	**90%**	**80%**	**90%**
Merrimac Place Assisted Living	0	0	**16**	**3**
K-Mart @ Low Street	0	0	**14**	0
Doe Run Dr. @ turnaround	0	0	**4**	0
Wildwood @ Quail Run Hollow	0	0	**24**	**1**
Low Street @ Murphy Street	0	0	**26**	**1**
3 Doe Run Drive	0	0	**3**	0
3 Charmanski Drive (Monitor)	**7**	0	**73**	**22**
Country Manor Rehab. & Nursing	**7**	0	**73**	**33**
Belleville School	0	0	**14**	0
Hale St. @ Squires Glen Drive	0	0	**18**	0
Day Care Center	**15**	0	**73**	**33**
Bresnahan School	0	0	**17**	0
Acute Care/Rehab Facility	0	0	**51**	**19**
Anna Jacques Hospital	0	0	**50**	**19**
Currier School	0	0	**21**	0
Knox Middle School	0	0	**37**	**2**
Newburyport High School	0	0	**40**	**5**
Elderly Housing off Low Street	0	0	**16**	0
Davenport School	0	0	**21**	0
Minimum number of exceedances predicted	0	0	3	0
Maximum number of exceedances predicted	15	0	73	33
Minimum number of exceedances if exceedances are predicted to occur.	7	---	3	1

Table C-2 Case 2B Hydrogen Sulfide Exceedances Modeling High Gas Flow Rate with Propane

Location	Number of hours per year predicted to exceed 42 ug/m^3 H_2S Model Efficiency Assumption		Number of hours per year predicted to exceed 14 ug/m^3 H_2S Model Efficiency Assumption	
	80%	**90%**	**80%**	**90%**
Merrimac Place Assisted Living	16	**5**	**52**	**23**
K-Mart @ Low Street	0	0	**61**	**2**
Doe Run Dr. @ turnaround	0	0	**4**	0
Wildwood @ Quail Run Hollow	**25**	**3**	**126**	**42**
Low Street @ Murphy Street	0	0	**96**	0
3 Doe Run Drive	0	0	**16**	**1**
3 Charmanski Drive (Monitor)	**83**	**29**	**351**	**139**
Country Manor Rehab. & Nursing	**77**	**24**	**302**	**130**
Belleville School	**2**	0	**46**	**9**
Hale St. @ Squires Glen Drive	**13**	0	**69**	**39**
Day Care Center	**83**	**27**	**282**	**131**
Bresnahan School	**12**	0	**60**	**28**
Acute Care/Rehab Facility	**51**	**6**	**109**	**68**
Anna Jacques Hospital	**47**	**10**	**130**	**64**
Currier School	**19**	0	**51**	**28**
Knox Middle School	**34**	0	**80**	**55**
Newburyport High School	**41**	0	**84**	**54**
Elderly Housing off Low Street	**8**	0	**45**	**22**
Davenport School	**14**	0	**49**	**32**
Minimum number of exceedances predicted	0	0	4	0
Maximum number of exceedances predicted	83	29	351	139
Minimum number of exceedances if exceedances are predicted to occur.	2	3	4	1

Table C-3 Case 2B Sulfur Dioxide Exceedances Modeling High Gas Flow Rate with Propane

Location	Number of hours per year predicted to exceed 660 ug/m^3 SO_2 Assuming 100% of Sulfur to SO_2	Number of hours per year predicted to exceed 660 ug/m^3 SO_2 Assuming 80% of Sulfur to SO_2*
Merrimac Place Assisted Living	**12**	**9**
K-Mart @ Low Street	0	0
Doe Run Dr. @ turnaround	0	0
Wildwood @ Quail Run Hollow	**16**	**9**
Low Street @ Murphy Street	0	0
3 Doe Run Drive	0	0
3 Charmanski Drive (Monitor)	**58**	**41**
Country Manor Rehab. & Nursing	**48**	**33**
Belleville School	0	0
Hale St. @ Squires Glen Drive	0	0
Day Care Center	**52**	**36**
Bresnahan School	**1**	0
Acute Care/Rehab Facility	**26**	**13**
Anna Jacques Hospital	**32**	**21**
Currier School	**7**	0
Knox Middle School	**14**	**6**
Newburyport High School	**23**	**3**
Elderly Housing off Low Street	0	0
Davenport School	**1**	0
Minimum number of exceedances predicted	0	0
Maximum number of exceedances predicted	58	41
Minimum number of exceedances if exceedances are predicted to occur	1	3

* Based on the assumption of an 80% open flare destruction efficiency of sulfur chemicals, converting 80% to SO_2, with 20% of the sulfur chemical remaining as the input chemical.

Table C-4 Case 2B Carbonyl Sulfide Exceedances Modeling High Gas Flow Rate with Propane

Location	Number of hours per year predicted to exceed 42 ug/m^3 COS Model Efficiency Assumption		Number of hours per year predicted to exceed 14 ug/m^3 COS Model Efficiency Assumption	
	80%	**90%**	**80%**	**90%**
Merrimac Place Assisted Living	0	0	**3**	0
K-Mart @ Low Street	0	0	0	0
Doe Run Dr. @ turnaround	0	0	0	0
Wildwood @ Quail Run Hollow	0	0	**1**	0
Low Street @ Murphy Street	0	0	0	0
3 Doe Run Drive	0	0	0	0
3 Charmanski Drive (Monitor)	0	0	**16**	0
Country Manor Rehab. & Nursing	0	0	**14**	0
Belleville School	0	0	0	0
Hale St. @ Squires Glen Drive	0	0	0	0
Day Care Center	0	0	**22**	0
Bresnahan School	0	0	0	0
Acute Care/Rehab Facility	0	0	0	0
Anna Jacques Hospital	0	0	**4**	0
Currier School	0	0	0	0
Knox Middle School	0	0	0	0
Newburyport High School	0	0	0	0
Elderly Housing off Low Street	0	0	0	0
Davenport School	0	0	0	0
Minimum number of exceedances predicted	0	0	0	0
Maximum number of exceedances predicted	0	0	22	0
Minimum number of exceedances if exceedances are predicted to occur	---	---	1	---

APPENDIX D

AALs and TELs

(December, 1995)

Massachusetts Threshold Effects Exposure Limits (TELs) and Allowable Ambient Limits (AALs) for Ambient Air

CHEMICAL	CAS NUMBER	Threshold Effects Exposure Limit (TEL)		Allowable Ambient Limit (AAL)	
		(24-hour average)		(annual average)	
		$\mu g/m^3$	(ppb)	$\mu g/m^3$	(ppb)
* Acetaldehyde	75070	2	(1.11)	0.5	(0.28)
Acetone	67641	160.54	(68.03)	160.54	(68.03)
* Acrylonitrile	107131	0.4	(0.18)	0.01	(0.0046)
Alkanes/Alkenes (not to exceed 25% n-hexane)		95.24	-	47.62	-
* Ammonia	7664417	100	(143.57)	100	(143.57)
* Aniline	62533	0.2	(0.053)	0.1	(0.026)
Antimony	7440360	2	-	1	-
Arsenic	7440382	0.0005	-	0.0002	-
Asbestos	1332214	0.0002 f/cm3		0.000004 f/cm3	
Benzene	71432	1.74	(0.54)	0.12	(0.04)
Benzyl Chloride	100447	14.08	(2.72)	0.94	(0.18)
Beryllium	7440417	0.001	-	0.0004	-
1,3-Butadiene	106990	1.20	(0.54)	0.003	(0.002)
n-Butyl Alcohol	71363	412.24	(136.05)	412.24	(136.05)
Cadmium	7440439	0.003	-	0.001	-
Calcium Chromate	13765190	0.003	-	0.0001	-
Carbon Disulfide	75150	0.1	(0.032)	0.1	(0.032)
Carbon Tetrachloride	56235	85.52	(13.61)	0.07	(0.01)
Carbonyl Sulfide	463581	0.1	(0.041)	0.1	(0.041)
Chlordane	57749	0.14	(0.008)	0.03	(0.002)
Chlorine	7782505	3.95	(1.36)	3.95	(1.36)
Chlorobenzene	108907	93.88	(20.41)	6.26	(1.36)

CHEMICAL	CAS NUMBER	Threshold Effects Exposure Limit (TEL)		Allowable Ambient Limit (AAL)	
		(24-hour average)		(annual average)	
		$\mu g/m^3$	(ppb)	$\mu g/m^3$	(ppb)
Chloroethane	75003	717.55	(272.11)	358.78	(136.05)
Chloroform	67663	132.76	(27.21)	0.04	(0.01)
Chloroprene	126998	0.98	(0.27)	0.98	(0.27)
Chromic Acid	7738945	0.003	-	0.0001	-
Chromium (metal)	7440473	1.36	-	0.68	-
Chromium (VI) Compounds		0.003	-	0.0001	-
Copper	7440508	0.54	-	0.54	-
p-Cresol	106445	24.05	(5.44)	12.02	(2.72)
Cyclohexane	110827	280.82	(81.63)	280.82	(81.63)
o-Dichlorobenzene	95501	81.74	(13.61)	81.74	(13.61)
p-Dichlorobenzene	106467	122.61	(20.41)	0.18	(0.03)
1,2-Dichloroethane	107062	11.01	(2.72)	0.04	(0.01)
1,2-Dichloroethylene	540590	215.62	(54.42)	107.81	(27.21)
Dichloromethane	75092	9.45	(2.72)	0.24	(0.07)
* 1,2-Dichloropropane	78875	0.9	(0.19)	0.05	(0.01)
Diethylamine	109897	8.13	(2.72)	4.07	(1.36)
Di(2-ethylhexyl)phthalate	117817	1.36	(0.09)	0.77	(0.05)
* Dimethylformamide	68122	6	(2.01)	3	(1.004)
1,4-Dioxane	123911	24.49	(6.80)	0.24	(0.07)
Diphenyl	92524	0.34	(0.05)	0.09	(0.01)
Diphenylamine	122394	2.72	(0.39)	0.68	(0.10)
* Epichlorohydrin	106898	0.08	(0.021)	0.08	(0.021)
Ethanol	64175	51.24	(27.21)	51.24	(27.21)
Ethyl Acetate	141786	391.84	(108.84)	391.84	(108.84)
Ethyl Acrylate	140885	0.56	(0.14)	0.28	(0.07)
* Ethylbenzene	100414	300	(69.09)	300	(69.09)
Ethylene Glycol	107211	34.50	(13.61)	34.50	(13.61)

CHEMICAL	CAS NUMBER	Threshold Effects Exposure Limit (TEL)		Allowable Ambient Limit (AAL)	
		(24-hour average)		(annual average)	
		$\mu g/m^3$	(ppb)	$\mu g/m^3$	(ppb)
Ethyl Ether	60297	329.80	(108.84)	164.90	(54.42)
Fluoride	16984488	6.80	(8.76)	6.80	(8.76)
Formaldehyde	50000	0.33	(0.27)	0.08	(0.06)
Furan	110009	0.40	(0.14)	0.02	(0.007)
Heptachlor	76448	0.14	(0.009)	0.001	(0.0001)
Hexachlorocyclopentadiene	77474	0.006	(0.0005)	0.006	(0.0005)
Hexachloroethane	67721	0.53	(0.05)	0.25	(0.03)
2-Hexanone	591786	10.88	(2.66)	10.88	(2.66)
Hydrazine	302012	0.007	(0.005)	0.002	(0.001)
Hydrogen Bromide	10035106	5	(1.51)	5	(1.51)
* Hydrogen Chloride	7647010	7	(4.69)	7	(4.69)
* Hydrogen Cyanide	74908	0.6	(0.54)	0.3	(0.27)
Hydrogen Fluoride	7664393	0.68	(0.83)	0.34	(0.42)
* Hydrogen Sulfide	7783064	0.9	(0.65)	0.9	(0.65)
Isoamyl Acetate	123922	144.76	(27.21)	144.76	(27.21)
Isobutyl Acetate	110190	193.77	(40.82)	193.77	(40.82)
Isobutyl Alcohol	78831	41.22	(13.61)	41.22	(13.61)
Isopropyl Acetate	108214	283.81	(68.03)	283.81	(68.03)
Lead	7439921	0.14	-	0.07	-
Lead Subacetate	1335326	0.14	-	0.01	-
Lindane	58899	0.14	(0.11)	0.003	(0.0002)
Maleic Anhydride	108316	0.27	(0.07)	0.14	(0.03)
Mercury (elemental)	7439976	0.14	-	0.07	-
(inorganic)		0.14	-	0.01	-
(methylmercury)		0.003	-	0.0014	-
Methanol	67561	7.13	(5.44)	7.13	(5.44)
* 2-Methoxy Ethanol	109864	3	(0.96)	2	(0.64)

CHEMICAL	CAS NUMBER	Threshold Effects Exposure Limit (TEL)		Allowable Ambient Limit (AAL)	
		(24-hour average)		(annual average)	
		$\mu g/m^3$	(ppb)	$\mu g/m^3$	(ppb)
Methyl Acrylate	96333	9.57	(2.72)	4.79	(1.36)
Methyl Bromide	74839	5.28	(1.36)	2.64	(0.68)
* Methyl Ethyl Ketone (MEK)	78933	200	(67.82)	10	(3.39)
Methyl Isobutyl Ketone (MIBK)	108101	55.70	(13.61)	55.70	(13.61)
Methyl Methacrylate	80626	22.27	(5.44)	22.27	(5.44)
Naphthalene (including 2-methylnaphthalene)	91203	14.25	(2.72)	14.25	(2.72)
Nickel (metal)	7440020	0.27	-	0.18	-
Nickel Oxide	1313991	0.27	-	0.01	-
Nitrobenzene	98953	13.69	(2.72)	6.84	(1.36)
Pentachlorophenol	87865	0.01	(0.001)	0.01	(0.001)
Phenol	108952	52.33	(13.61)	52.33	(13.61)
Phosphoric Acid	7664382	0.27	(0.07)	0.27	(0.07)
Phthalic Anhydride	85449	1.65	(0.27)	0.82	(0.14)
PCBs	1336363	0.003	-	0.0005	-
Propyl Alcohol	71238	133.63	(54.42)	133.63	(54.42)
* Propylene Oxide	75569	6	(2.53)	0.3	(0.13)
Resorcinol	108463	12.24	(2.72)	3.06	(0.68)
Selenium	7782492	0.54	-	0.54	-
Selenium Sulfide	7446346	0.54	-	0.05	-
* Styrene	100425	200	(46.96)	2	(0.47)
Sulfuric Acid	7664939	2.72	(0.68)	2.72	(0.68)
1,1,2,2-Tetrachloro-1,2-Difluoroethane	76120	1133.33	(136.05)	566.67	(68.03)
1,1,2,2-Tetrachloroethane	79345	18.67	(2.72)	0.02	(0.003)
Tetrachloroethylene	127184	922.18	(136.05)	0.02	(0.003)
Tetrahydrofuran	109999	160.35	(54.42)	80.18	(27.21)

CHEMICAL	CAS NUMBER	Threshold Effects Exposure Limit (TEL)		Allowable Ambient Limit (AAL)	
		(24-hour average)		(annual average)	
		$\mu g/m^3$	(ppb)	$\mu g/m^3$	(ppb)
* Toluene	108883	80	(21.23)	20	(5.31)
Toluene Diisocyanate	584849	0.10	(0.01)	0.10	(0.01)
o-Toluidine	95534	2.38	(0.54)	0.17	(0.04)
1,1,1-Trichloroethane	71556	1038.37	(190.48)	1038.37	(190.48)
1,1,2-Trichloroethane	79005	14.84	(2.72)	0.06	(0.01)
Trichloroethylene	79016	36.52	(6.80)	0.61	(0.11)
2,4,6-Trichlorophenol	88062	-	-	0.16	-
* Triethylamine	121448	1	(0.24)	0.7	(0.17)
Vanadium	1314621	0.27	-	0.27	-
Vanadium Pentoxide	1314621	0.14	(0.02)	0.03	(0.005)
* Vinyl Acetate	108054	30	(8.52)	8	(2.27)
Vinyl Chloride	75014	3.47	(1.36)	0.38	(0.15)
Vinylidene Chloride	75354	1.08	(0.27)	0.02	(0.01)
Xylenes (m-,o-,p- isomers)	1330207	11.80	(2.72)	11.80	(2.72)

All new and revised values are expressed in ug/m^3 to one significant figure. To allow for more accurate interconversion between ug/m^3 and ppb, no rounding of the ppb-equivalent values was conducted.

New and revised criteria are shaded.

*Criteria which were derived based on an Environmental Protection Agency Reference Concentration (RfC)